

# Great Lakes Tunnel Project

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**Design, Construction, and Operations Information Session**

# Safety Moment

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**Lifesaving Rule #1: Hazard Management**

# Enbridge Lifesaving Rules



Rule 1  
Hazard Management



Rule 2  
Driving Safety



Rule 3  
Confined Space Entry



Rule 4  
Ground  
Disturbance



Rule 5  
Isolation of  
Energized Systems



Rule 6  
Reporting Safety  
Incidents



Rule 7  
Bypassing Safety  
Controls

- Each Lifesaving Rule focuses on an area of high risk and consequence
- The rules are intended to heighten awareness

# Life Saving Rule #1: Hazard Management

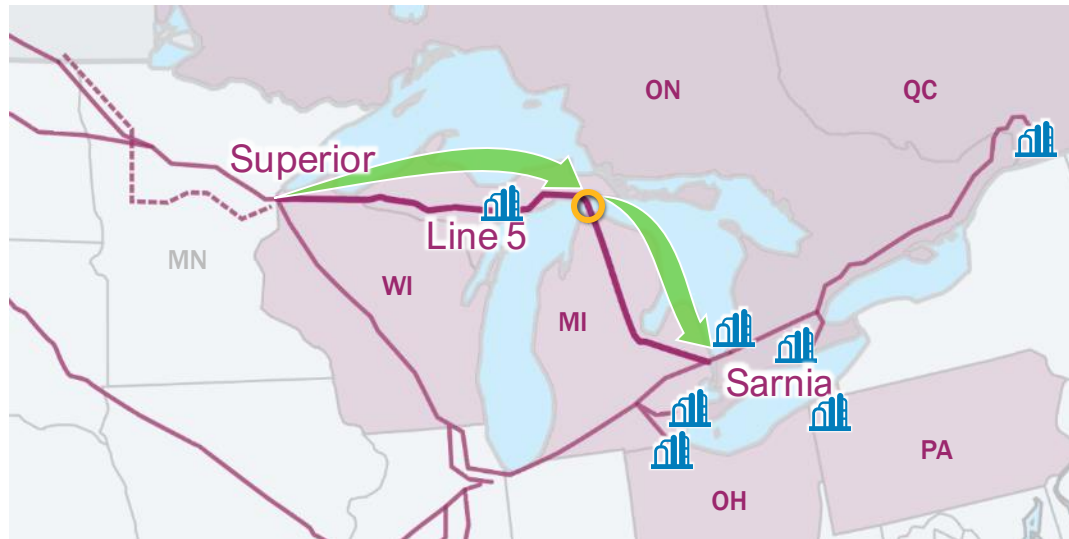


I will complete a hazard assessment prior to starting work and reassess if conditions change and new hazards are introduced.

- The assessment is meant to identify, assess and control the field-based hazards of the work being performed
- Examples of questions to be addressed:
  - Have we identified hazards today? Is it documented?
  - Did everyone on the crew have an opportunity to provide input?
  - Have results from the assessments been communicated to all workers?
  - Do we have effective controls in place and are they in compliance to the Enbridge Safety Manual, local legislation and the Contractors Program?

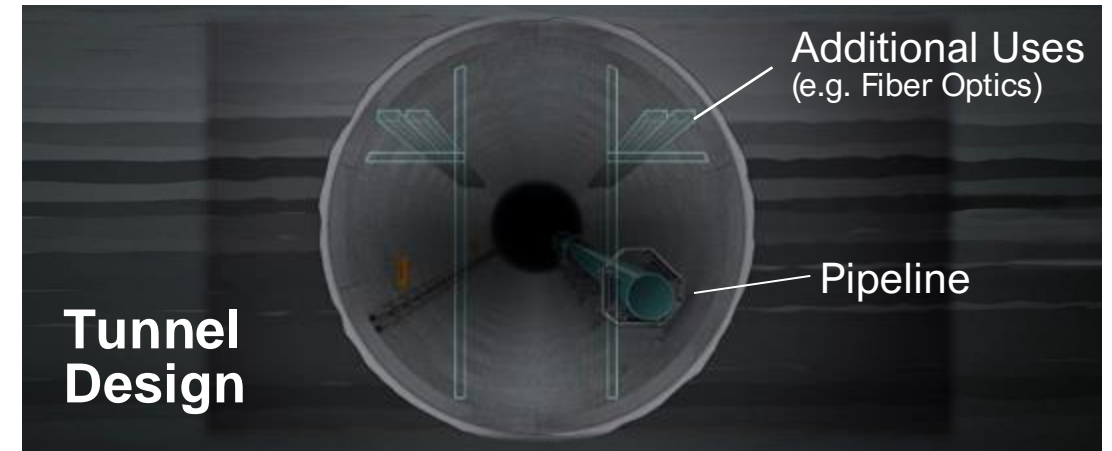
# Line 5 Update

## Critical Infrastructure



- Delivers on average **540** kbpd of crude and NGLs to 10 refineries in Michigan, Ohio, Pennsylvania, Ontario and Quebec

## Great Lakes Tunnel Project



### State Permitting:

- ✓ EGLE<sup>1</sup> Permits Awarded
- MPSC<sup>2</sup> Approval (*In Progress*)

### Federal Permitting:

- USACE<sup>3</sup> permit (*In Progress*)

### Contracting:

- ✓ Engineering & Design Phase
- Preparation for Construction Phase (*Commencing*)

Committed to ensuring the safe and reliable delivery of essential energy supply

(1) Michigan Department of Environment, Great Lakes and Energy

(2) Michigan Public Service Commission (3) U.S. Army Corps of Engineers

# Meet the Speakers



**Jon Hurt**  
Subsurface Design  
Lead

**ARUP**



**Liza Dwyre**  
WSP Owner's  
Engineer



**Aaron Dennis**  
Tunnel Project  
Lead Engineer





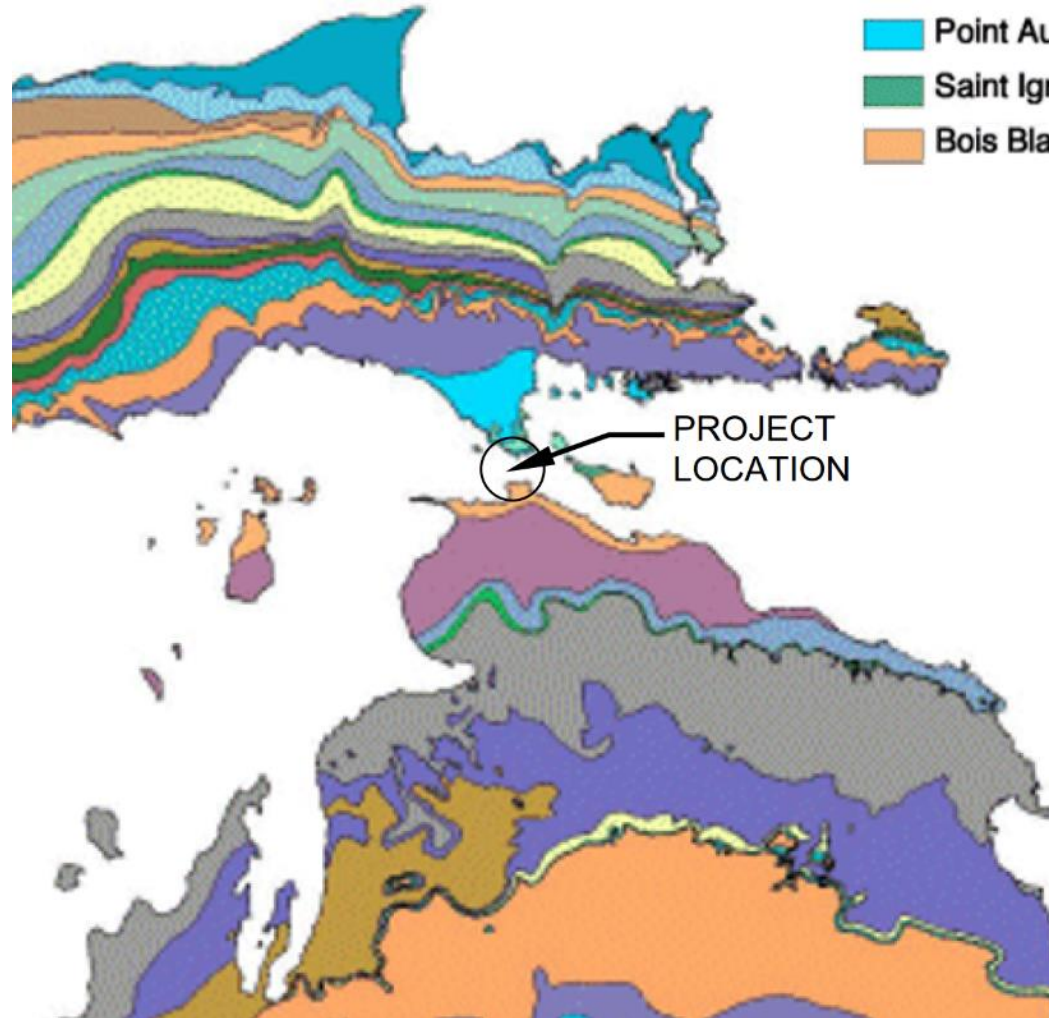
## STAGING + SETUP



# Ground Conditions

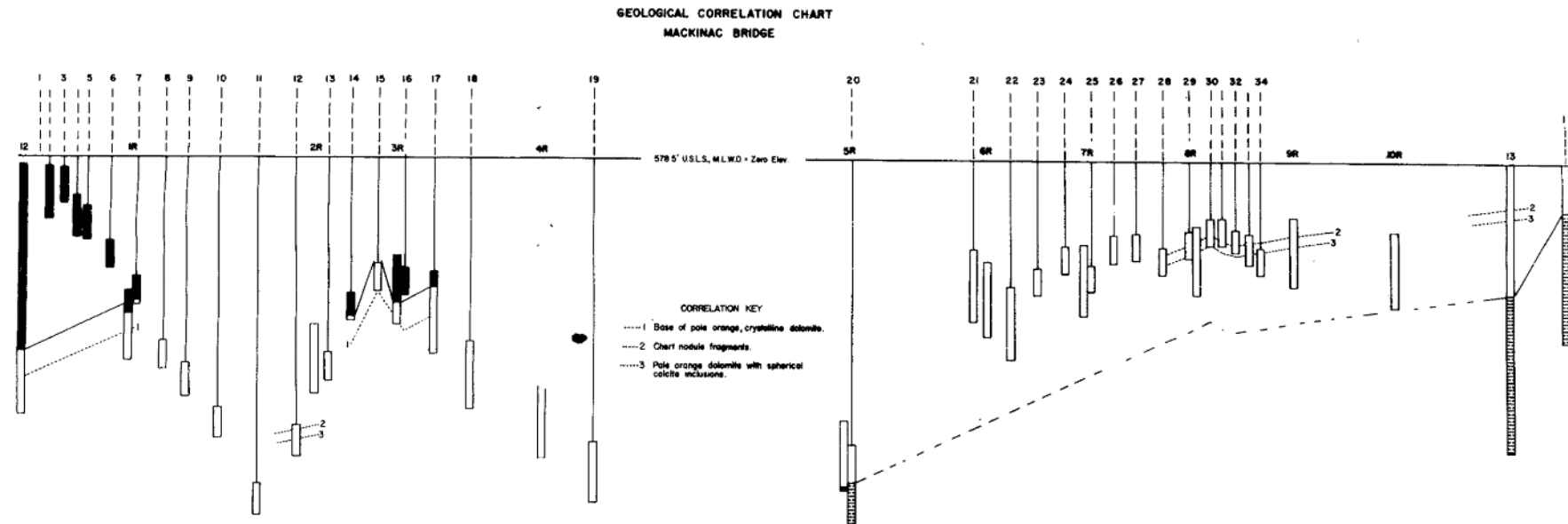
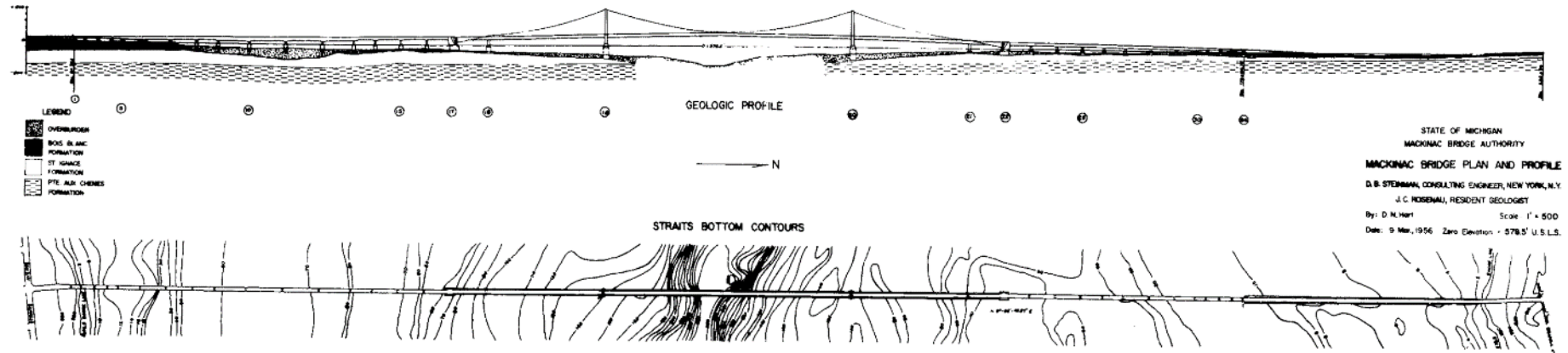
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# Regional Geologic Setting

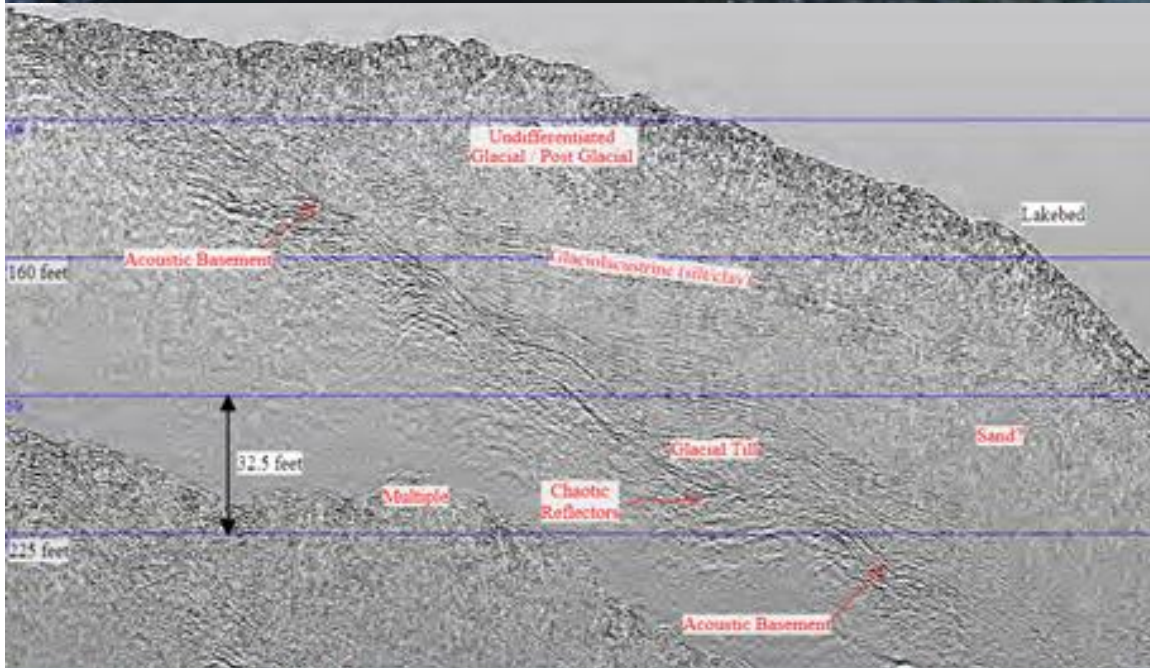


Michigan Bedrock Geology  
[Data sources are the 1:500,000 maps by R.L. Milstein, 1987, "Bedrock geology of southern Michigan", and R.C. Reed, "Bedrock geology of southern Michigan", published by the Michigan Department of Natural Resources.]

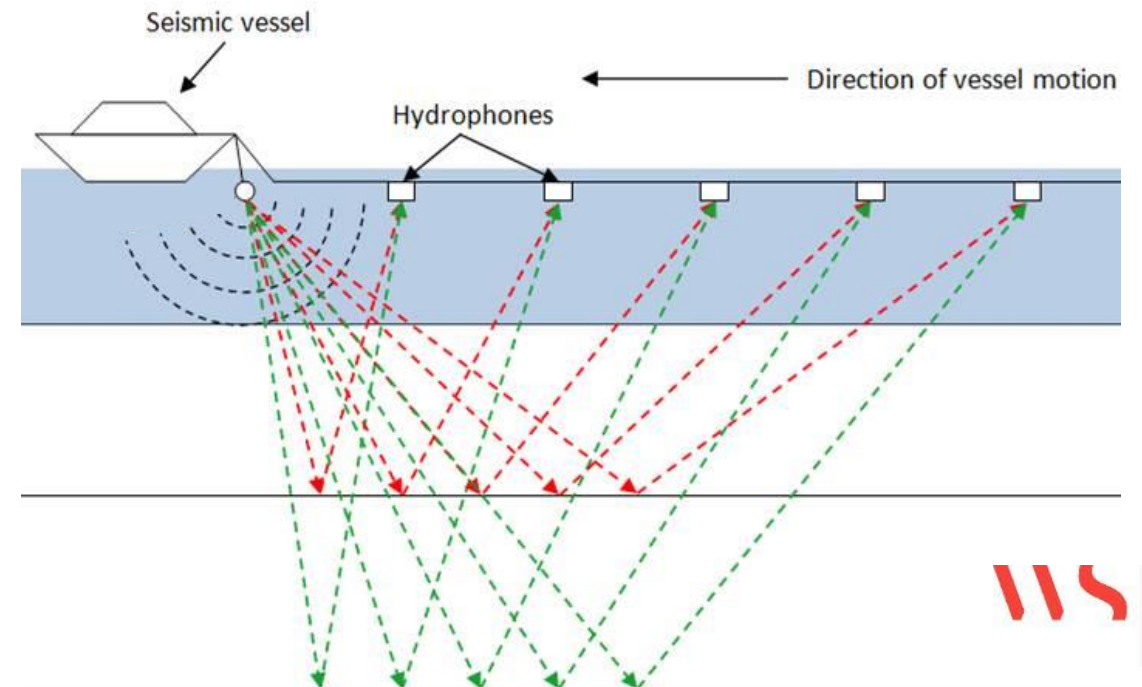
# Historical Data: Mackinac Bridge



# Marine Seismic Reflection/Refraction Survey (2018)



- Data is interpreted to characterize the subsurface geologic conditions and geologic structure



Ground Conditions

# Boring Locations



# Onshore, Nearshore, and Deepwater Borings

South Shore



Jack-up Barge

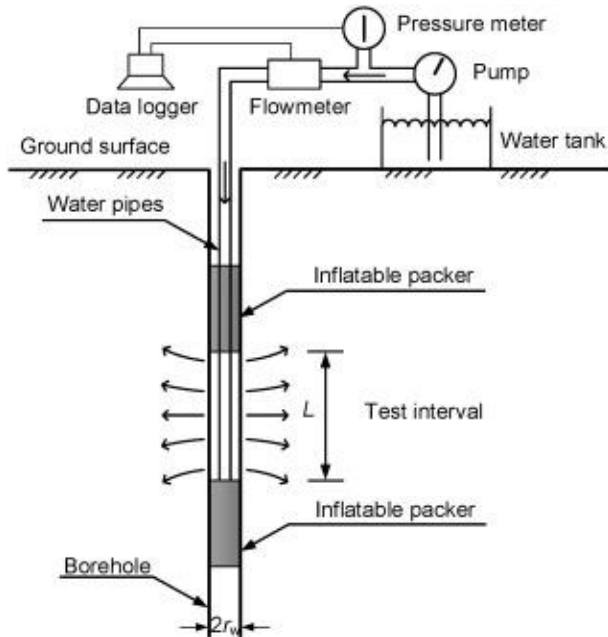


Dynamically-positioned Drill Ship



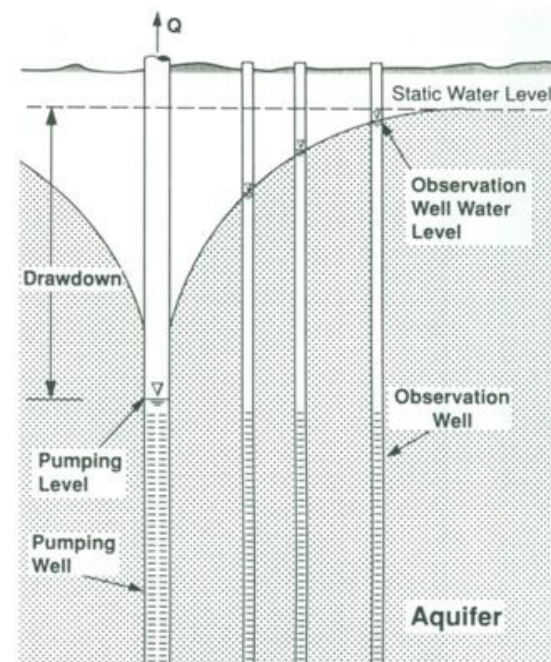
# Hydraulic Conductivity (permeability)

## Packer Test



- Water is pushed into the rock formation under pressure
- Tests local zones, isolated between inflatable packers

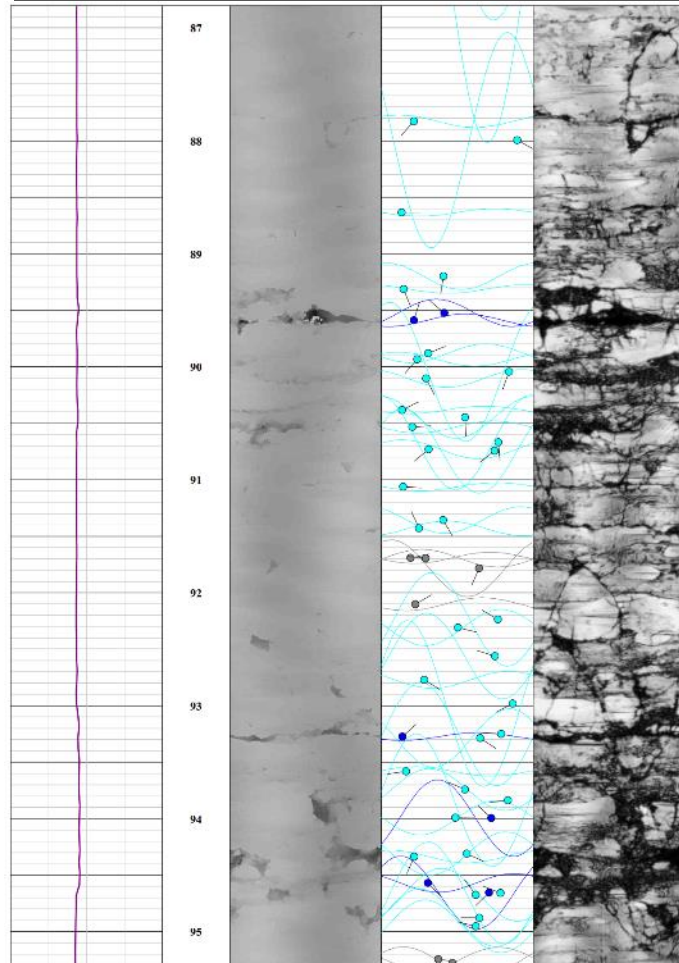
## Pump Test



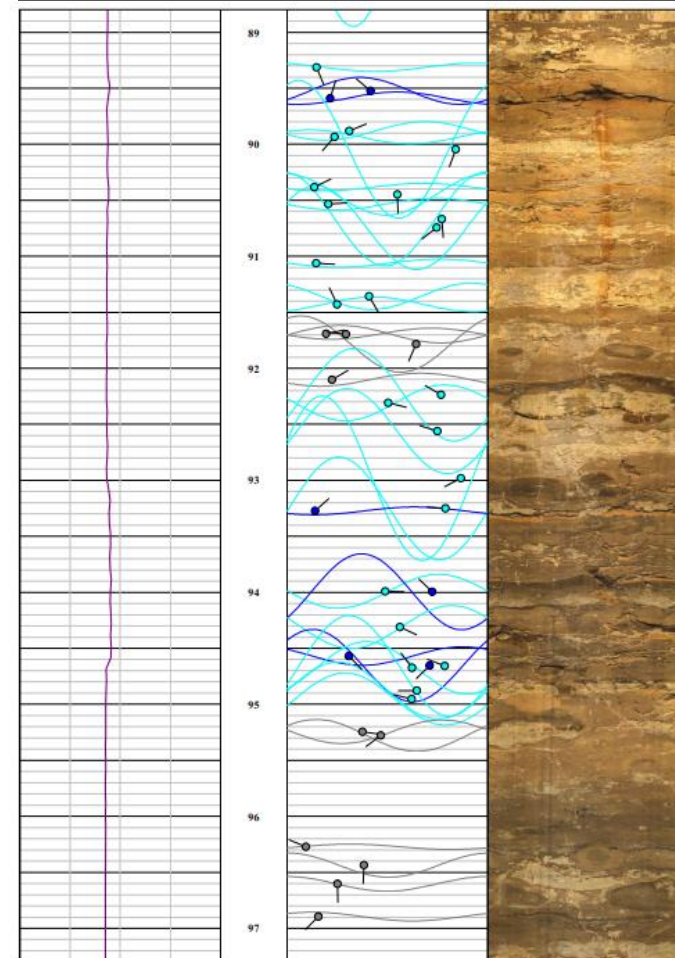
- Water is pumped out of the rock mass, from a pumping well
- Drawdown is measured in surrounding observation wells

# Borehole Geophysics

## Acoustic Televiewer



## Optical Televiewer



# Ground Conditions

# Laboratory Tests of Rock Properties



Client:	WSP	Project No:	GTX-310187
Project:	Line 5 Replacement and Tunnel Project	Tested By:	tlm
Location:	Straits of Mackinac	Checked By:	smd
Boring ID:	BH19-15	Sample Type:	cylinder
Sample ID:	LRS-005	Test Date:	07/30/19
Depth:	218.0-223.0 ft	Test ID:	514985
Test Comment:	---		
Visual Description:	---		
Sample Comment:	---		

## Axial Point Load Strength Index of Rock by ASTM D5731

Test No.	Specimen Depth	Diameter, in	Thickness, in	Failure Load (P), lbs	De, sq in	De, in	Is, psi	F	Is(50mm), psi	Generalized Correction Factor, K	Estimated Compressive Strength, psi
PLA-5	219.22 - 219.31 ft	2.36	1.12	286	3.37	1.84	85	0.969	82	19	1,610



Before



After

Intact Material Failure

Notes: Ge  
The  
De  
Is  
F =  
Is(5



Client:	WSP	Project No:	GTX-310187
Project:	Line 5 Replacement Tunnel	Tested By:	tlm
Location:	Straits of Mackinac	Checked By:	smd
Boring ID:	BH19-08	Sample Type:	cylinder
Sample ID:	LRS-001	Test Date:	08/28/19
Depth:	21.9 ft	Test ID:	519327
Test Comment:	---		
Visual Description:	---		
Sample Comment:	---		

## Splitting Tensile Strength of Intact Rock Core Specimens by ASTM D3967

Specimen Depth	Test No	Thickness (L), in	Diameter (D), in	Thickness to Diameter Ratio (L/D)	Failure Load (P), lbs	Splitting Tensile Strength, psi	Failure Type
21.9 ft	ST-8	1.41	2.39	0.59	5,533	1,800	1



Notes: Strain rate: 2.5%/min.  
ASTM requires the thickness to diameter ratio (L/D) of each test specimen to be between 0.2 and 0.75.  
The reported thickness (L) is the average of three measurements.  
The reported diameter (D) is the average of three measurements.  
Failure Type: 1 = Intact Material Failure; 2 = Discontinuity Failure; 3 = Intact Material and Discontinuity Failure  
(See all test photographs)



Client:	WSP	Project No:	GTX-310187
Project:	Line 5 Replacement and Tunnel Project	Tested By:	tlm
Location:	Straits of Mackinac	Checked By:	jsc
Boring ID:	BH19-23	Sample Type:	bag
Sample ID:	LRS-004	Test Date:	02/11/20
Depth:	127.99 ft	Test ID:	534914
Test Comment:	---		
Visual Description:	---		
Sample Comment:	---		

## Abrasiveness of Rock Using the Cerchar Method by ASTM D7625

Boring ID	Sample ID	Depth	Stylus No	Reading 1	Reading 2	Average	Comments
BH19-23	LRS-004	127.95 ft	1	1.1	0.9	1.00	
			2	0.8	0.4	0.60	
			3	1.5	1.5	1.50	
			4	1.1	1.4	1.25	
			5	1.3	1.5	1.40	
			Average CATs			1.15	
			Average CAI *			1.02	

CERCHAR Abrasiveness Index Classification Medium abrasiveness

Notes:

Test Surface: Saw Cut  
Moisture Condition: As Received  
Apparatus Type: Original CERCHAR  
Stylus Hardness: Rockwell Hardness 64/66 HRC  
Stylus Displacement Relative to Rock Fabric: Stylus 1 2: Normal; Stylus 4 5: Parallel  
\* CAI = (10.99 \* CATs) + 6.48  
CAI = CERCHAR Index for smooth (saw cut) surface  
CAI = CERCHAR Index for natural surface  
Comments:



Client:	WSP	Test Date:
Project Name:	Line 5 Replacement Tunnel	Tested By:
Project Location:	Straits of Mackinac	Checked By:
GTX #:	310187	Sample Type:

## Point Load Strength Index of Rock by ASTM D

Boring No.	Sample No.	Depth, ft	Test No.	Test Type	Width (W), in.	Depth (D), in.	Area, in <sup>2</sup>	Failure Load (P), lb	D <sub>50</sub> <sup>2</sup> , in <sup>2</sup>	D <sub>50</sub> , in.
BH19-33	LRS-001	122.85	PLL-19	Irregular Lump	5.96	2.15	18.92	6124	24.09	4.91



Notes: Generalized correction factor, K<sub>s</sub> used to estimate the compressive strength based on the specimen depth and ASTM D 5731 Table 1.  
D<sub>50</sub> = the equivalent core diameter  
P<sub>u</sub> = the uncorrected point load strength Index  
F = the size correction factor  
I<sub>s(50)</sub> = the size corrected point load strength Index



Client:	WSP
Project Name:	Line 5 Replacement and Tunnel Project
Project Location:	Straits of Mackinac
GTX #:	310187
Test Date:	11/7/2019
Tested By:	jck
Checked By:	smd
Boring ID:	BH19-32
Sample ID:	LRS 005
Depth:	126.67-127.66



After cutting and grinding



After break

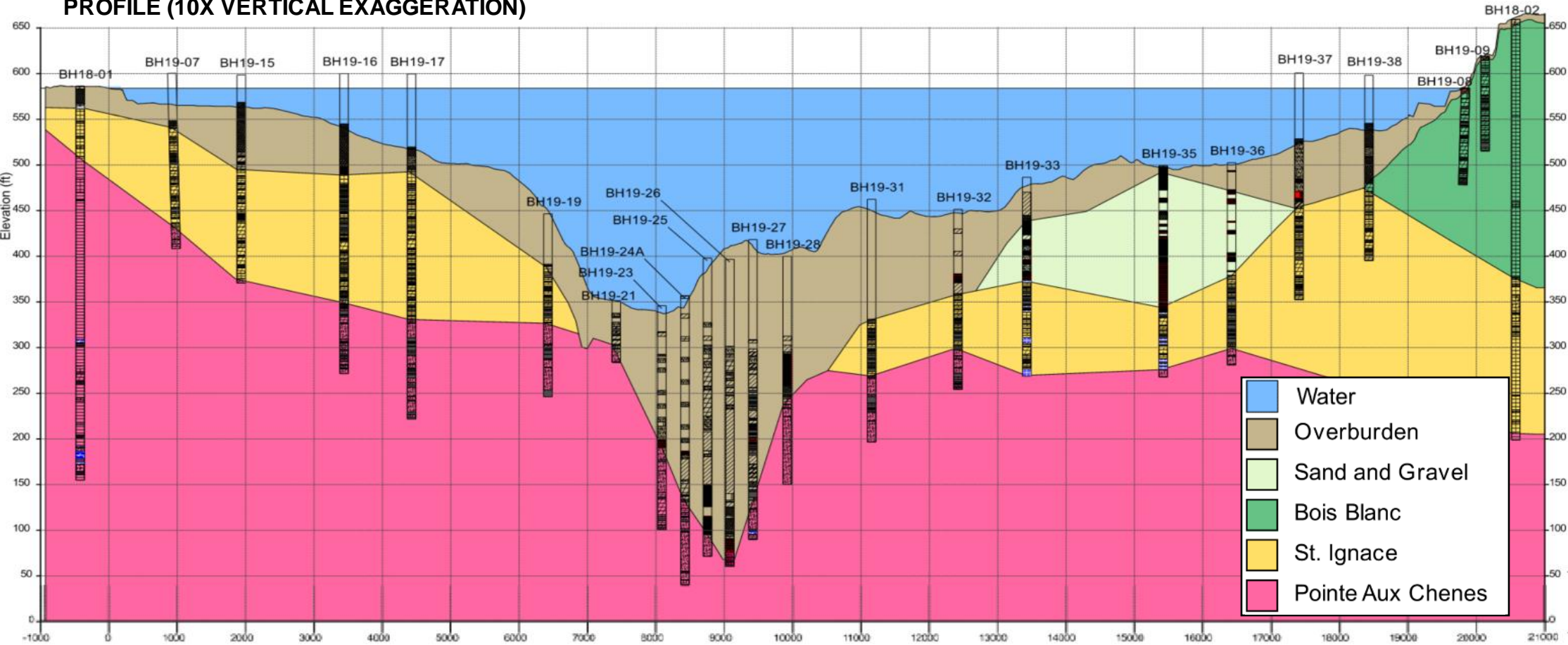


# Generalized Subsurface Profile

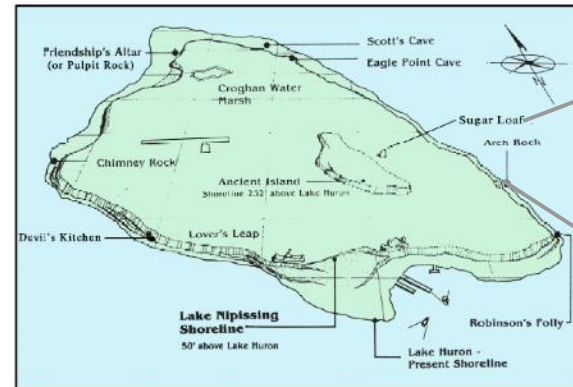
PROFILE (TRUE SCALE)



PROFILE (10X VERTICAL EXAGGERATION)



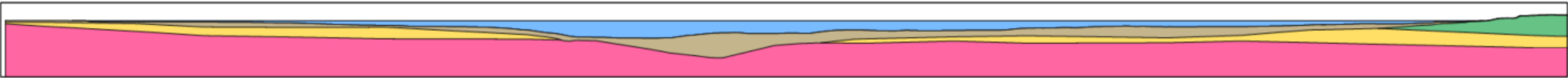
# Mackinac Breccia



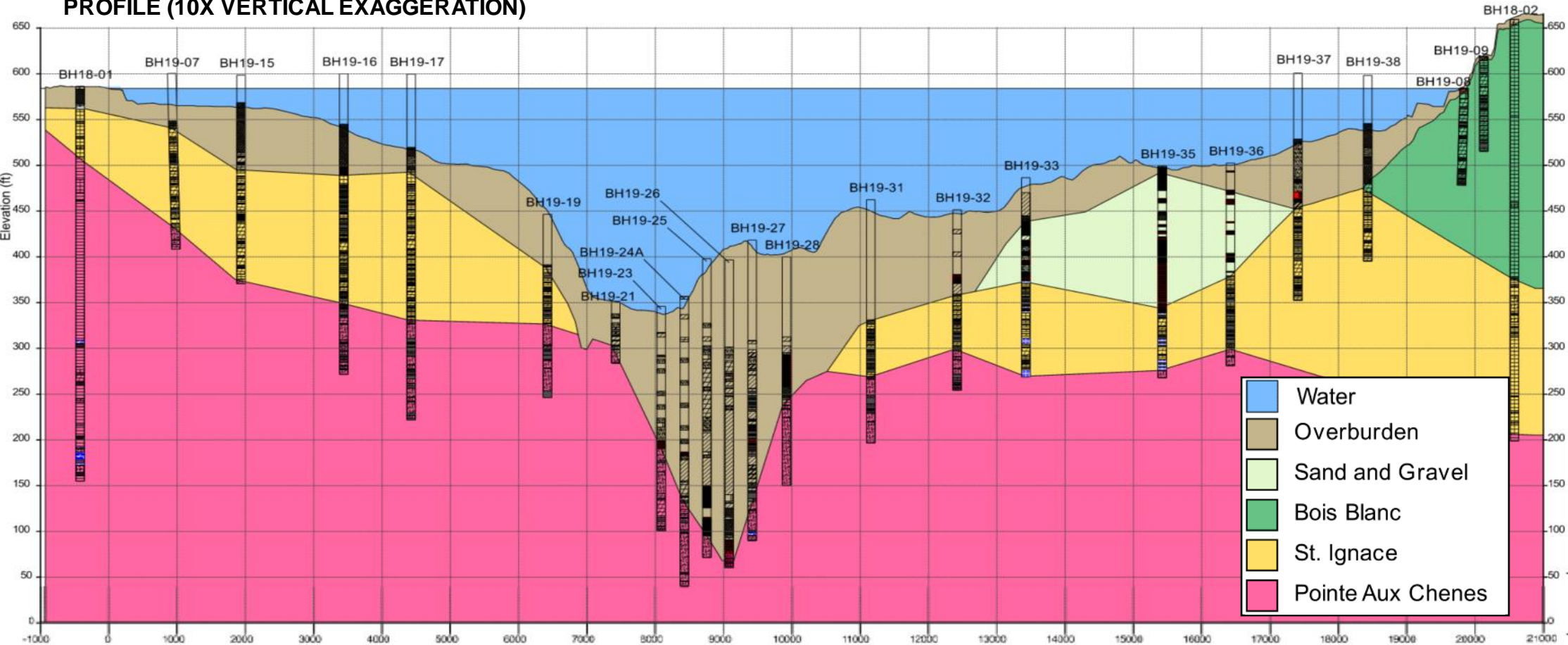
St. Anthony's Rock  
Located in St. Ignace, MI

# Generalized Subsurface Profile

PROFILE (TRUE SCALE)



PROFILE (10X VERTICAL EXAGGERATION)

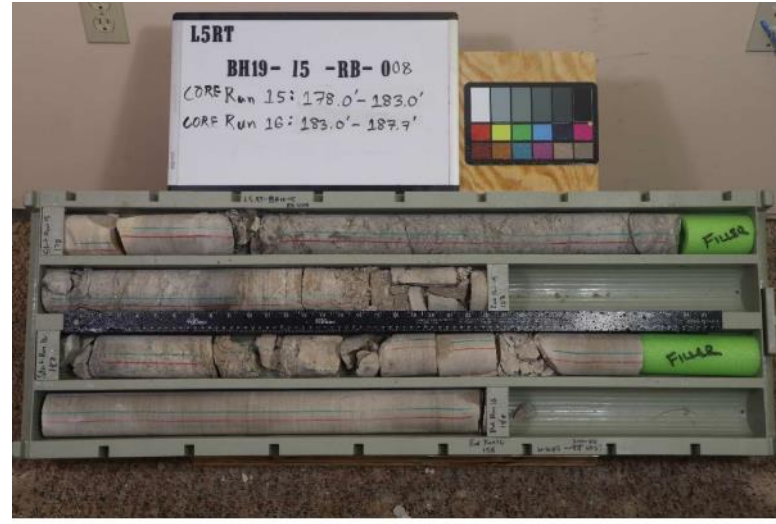


# Rock Core Examples from Each Formation



BH19-09-RB-001 (Wet)

Bois Blanc



BH19-15-RB-008 (Wet)

St Ignace



BH19-17-RB-016 (Wet)

Pointe Aux Chenes

# Geotechnical Evaluation

## Low Likelihood Conditions

- Deeper-than-expected buried valley
- Open voids (karst)
- Toxic/combustible gases

Not anticipated – but if they occur can be managed with some adaptations during tunneling

## Known Rock Conditions

- Variable ground conditions
- Some fractured, more permeable zones
- Claystones in Point Aux Chenes - weak rock, slaking

Rock parameters influence cutting tool wear and tunneling progress rates.

Managed with the specified TBM and construction methods

## Sufficient Geotechnical Data

- Borings most closely spaced in deep channel
  - Increased confidence in top of rock elevation

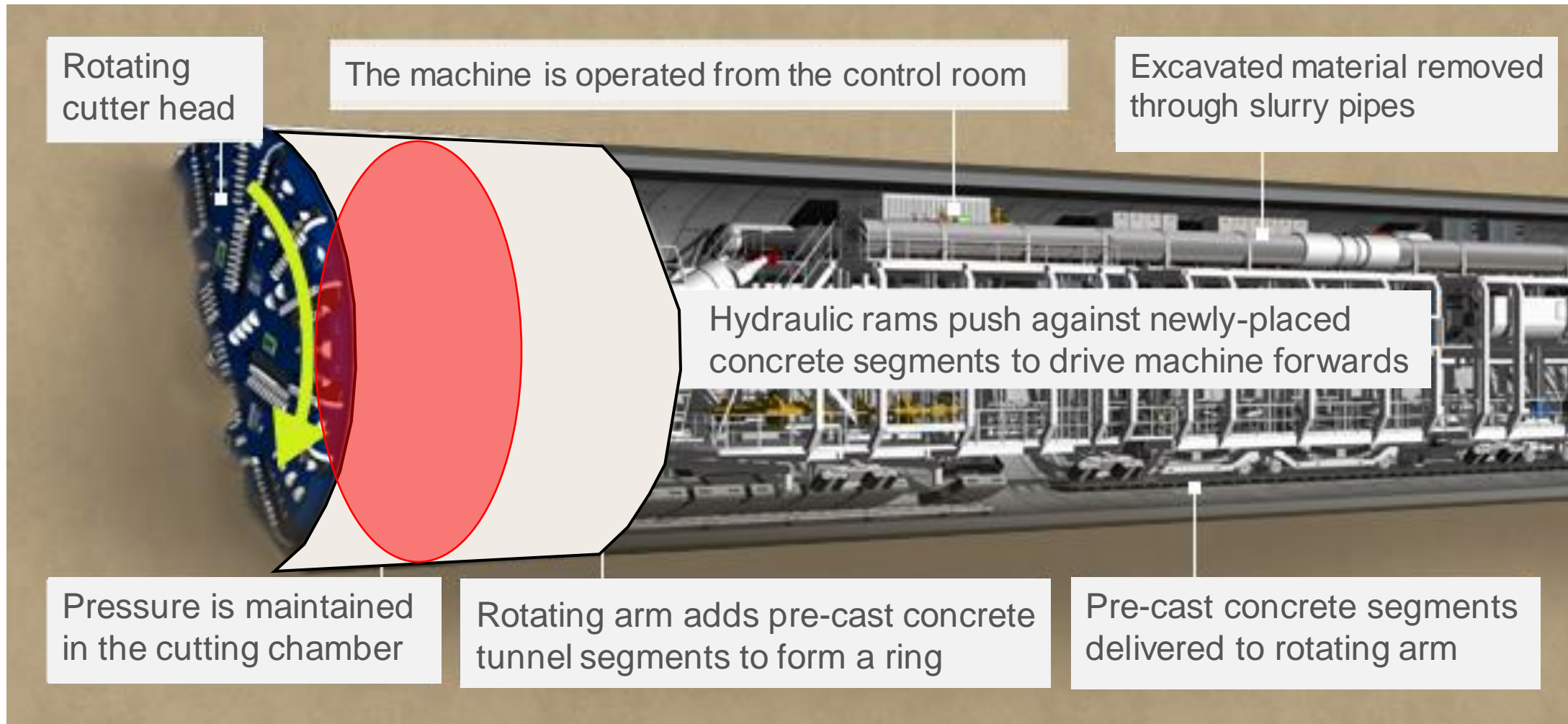
Geologic understanding and subsurface data provides a sufficient basis for tunnel design and state-of-the-practice TBM specifications

Understanding of the geotechnical conditions shaped the design approach

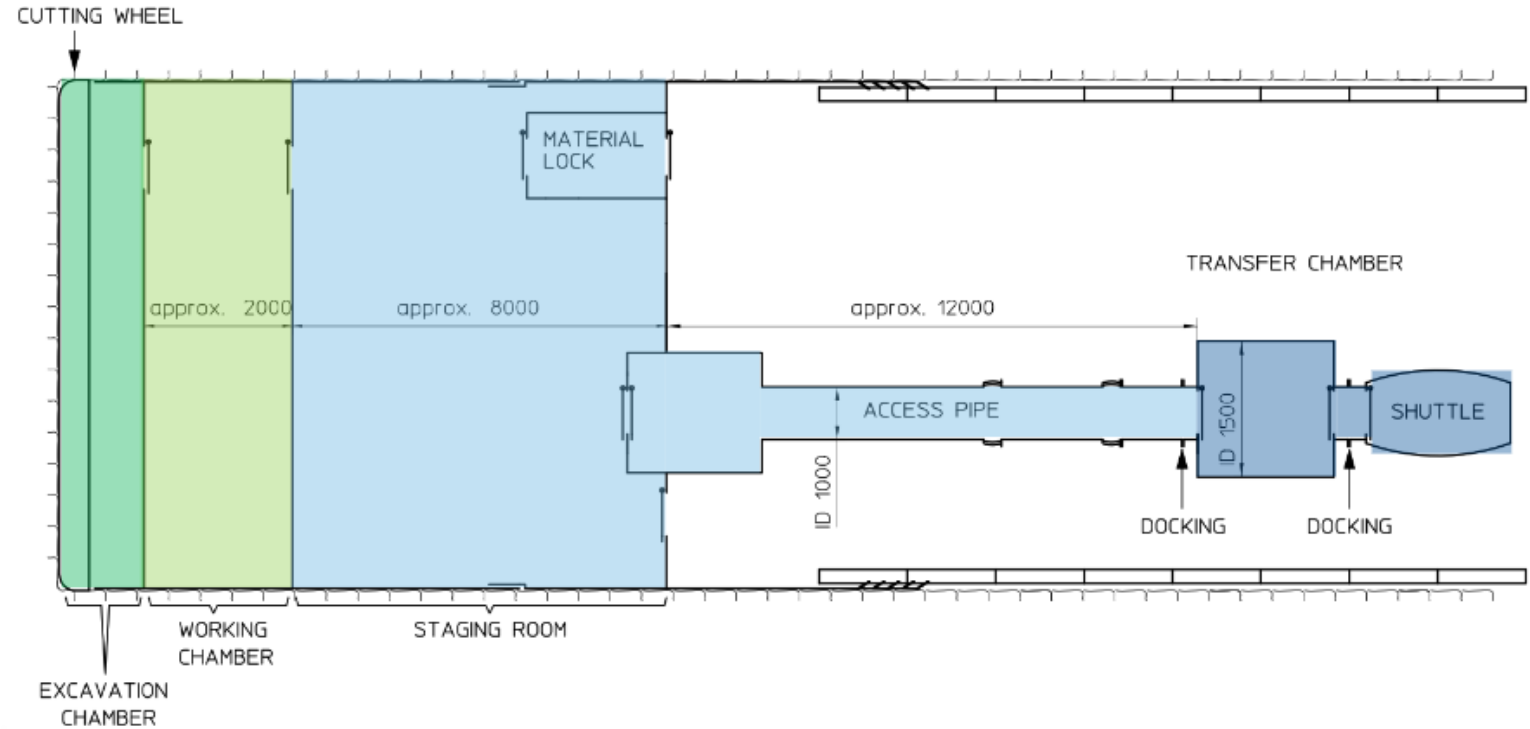
# Overall Design

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# Tunnel Boring Machine (TBM)

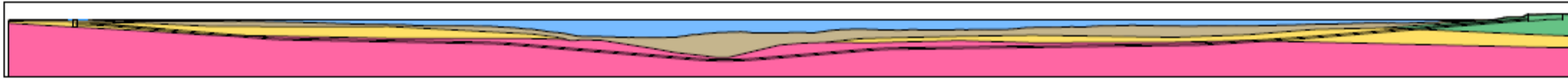


# TBM Interventions

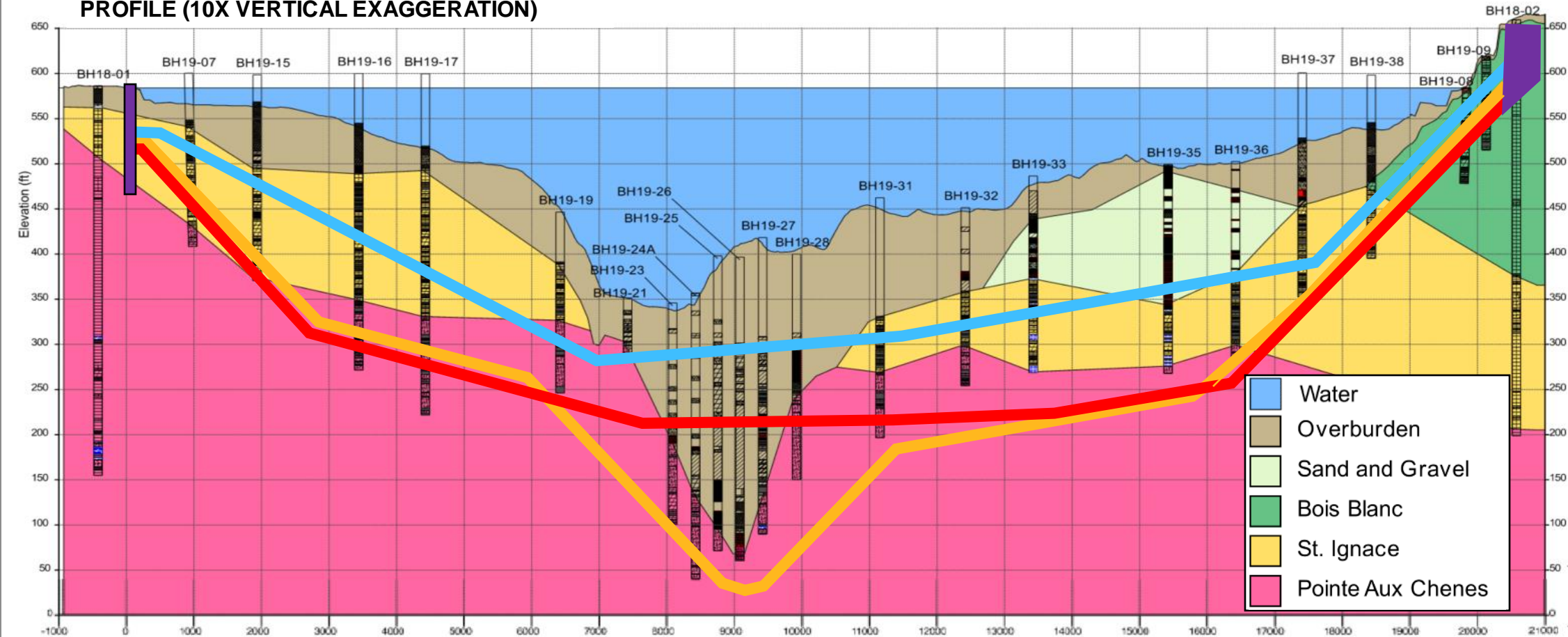


# Vertical Alignment

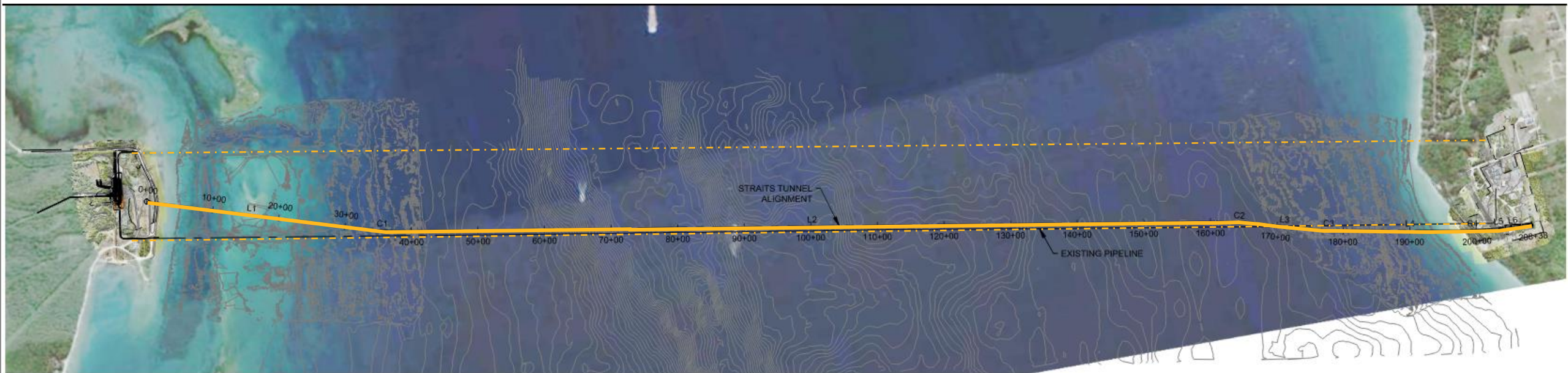
PROFILE (TRUE SCALE)



PROFILE (10X VERTICAL EXAGGERATION)

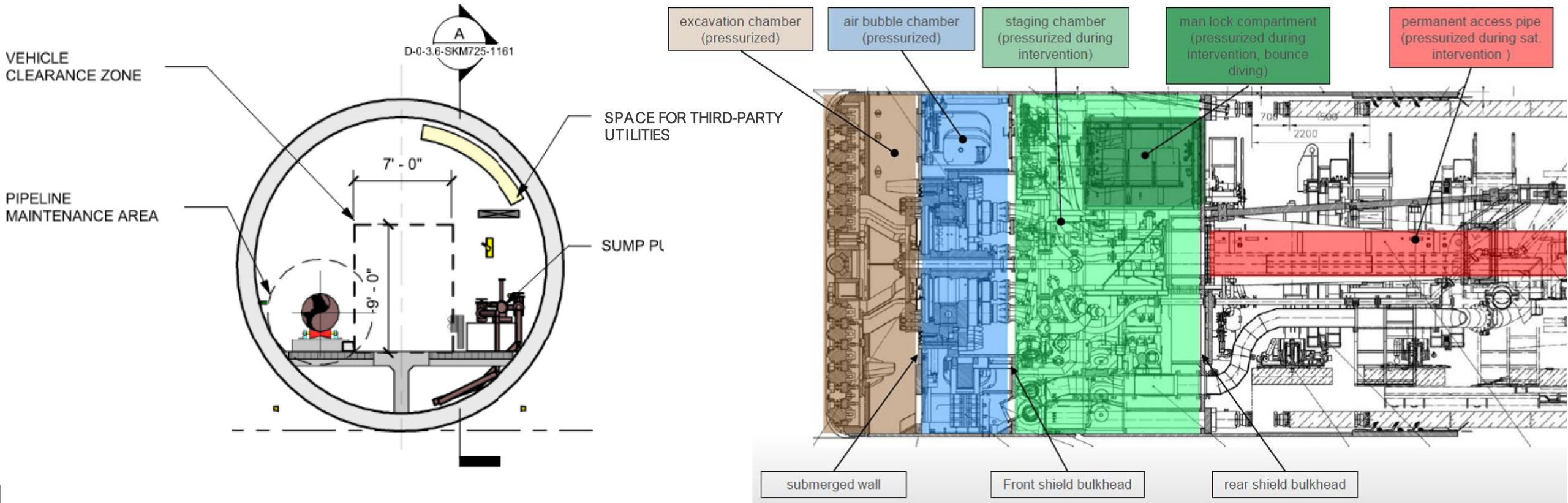


# Horizontal Alignment



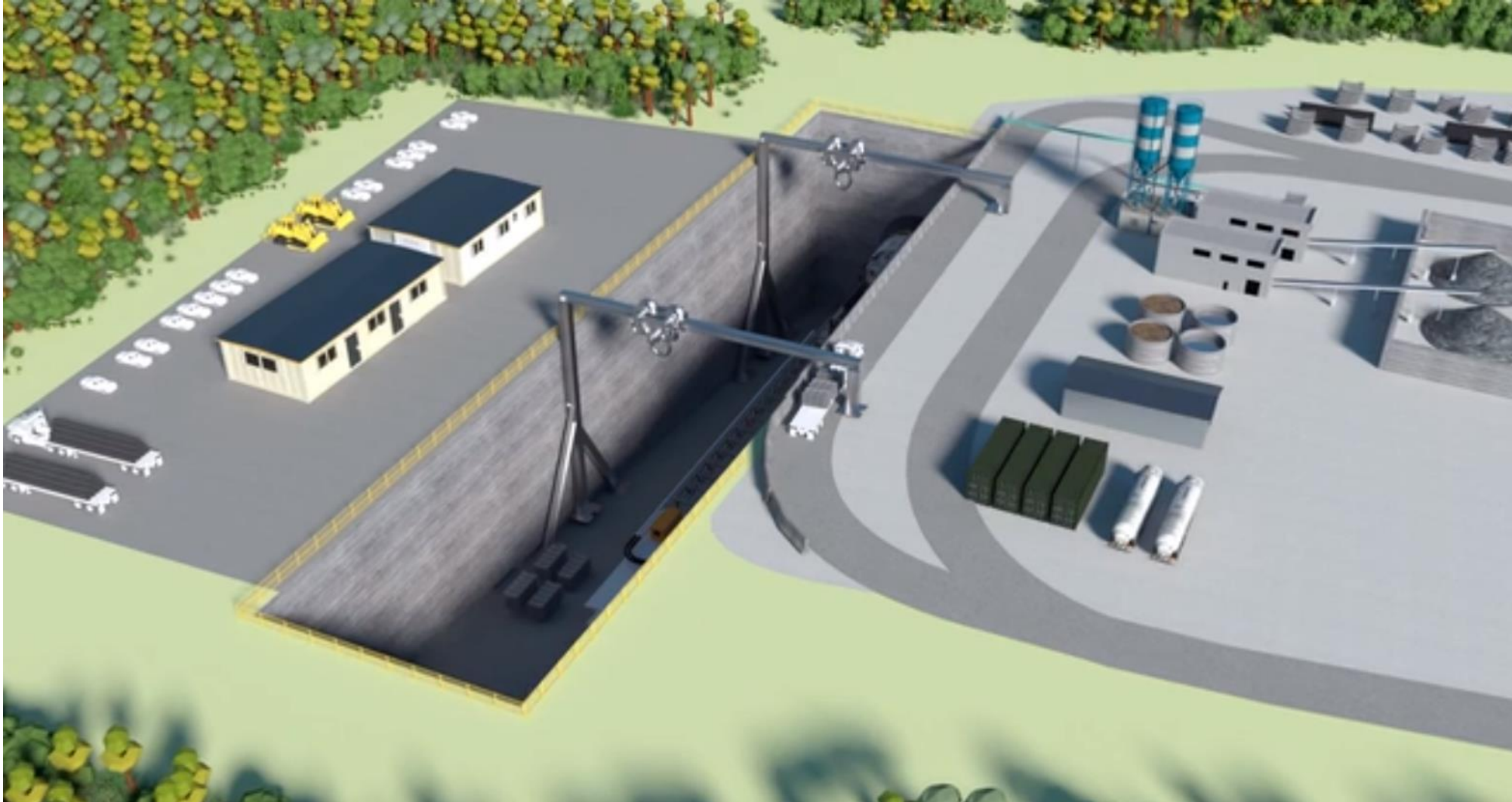
# Overall Design

## Tunnel Diameter



Overall Design

# Mackinaw Station Portal



ARUP

Overall Design

# North Straits Shaft

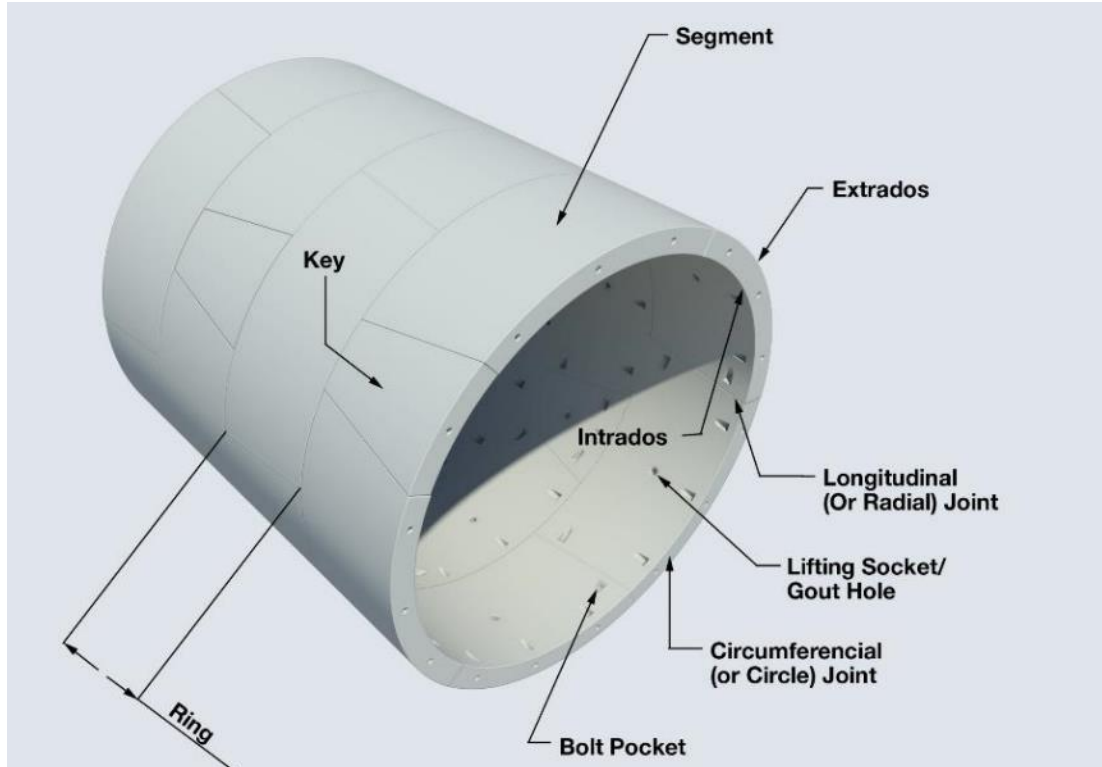


ARUP

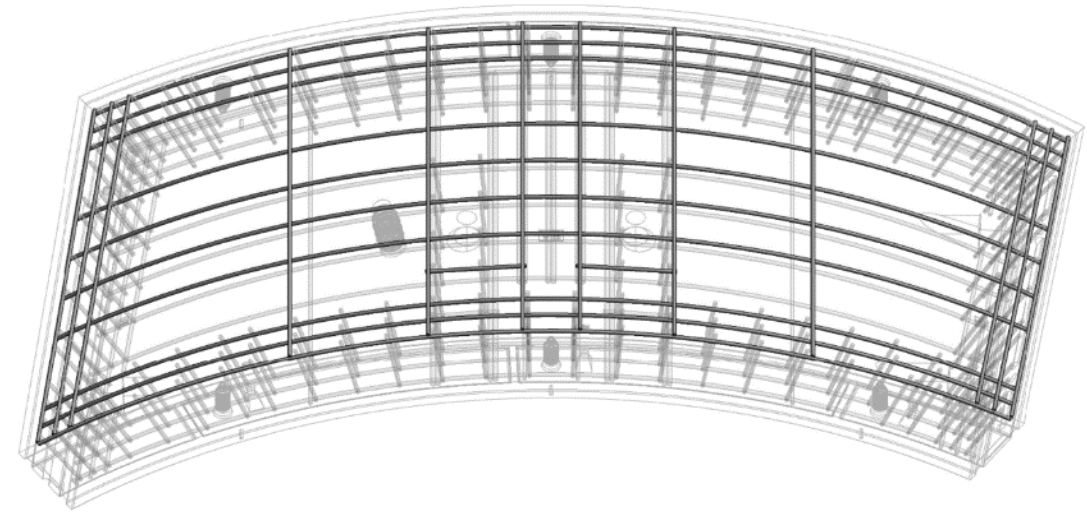
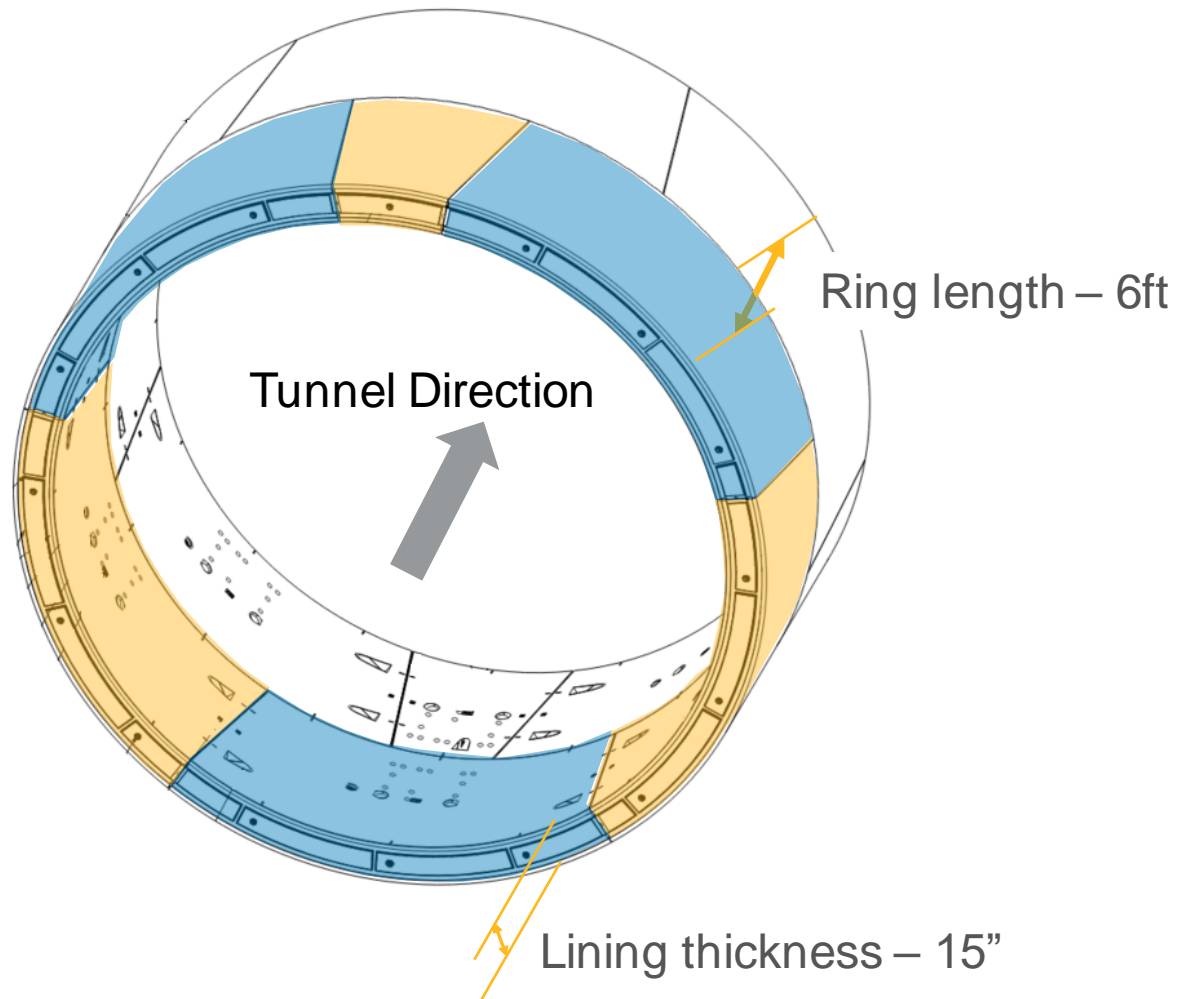
# Tunnel Lining

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# Precast Concrete Tunnel Lining (PCTL)

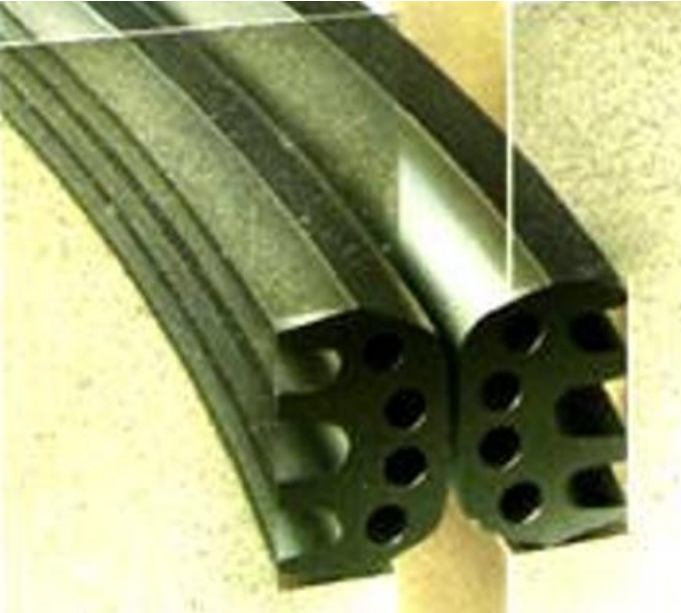


# Precast Concrete Tunnel Lining



Typical Rebar

# Tunnel Lining Gaskets



# Break – 10mins

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# Tunnel Construction

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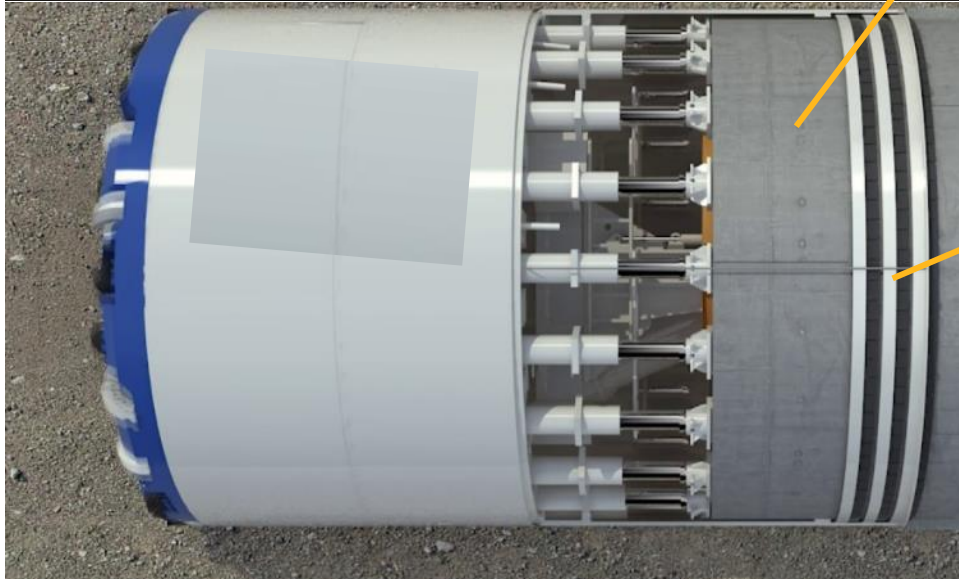
# Tunnel Construction TBM Tunneling



The shield of the TBM prevents water, soil and rock from entering the tunnel during construction

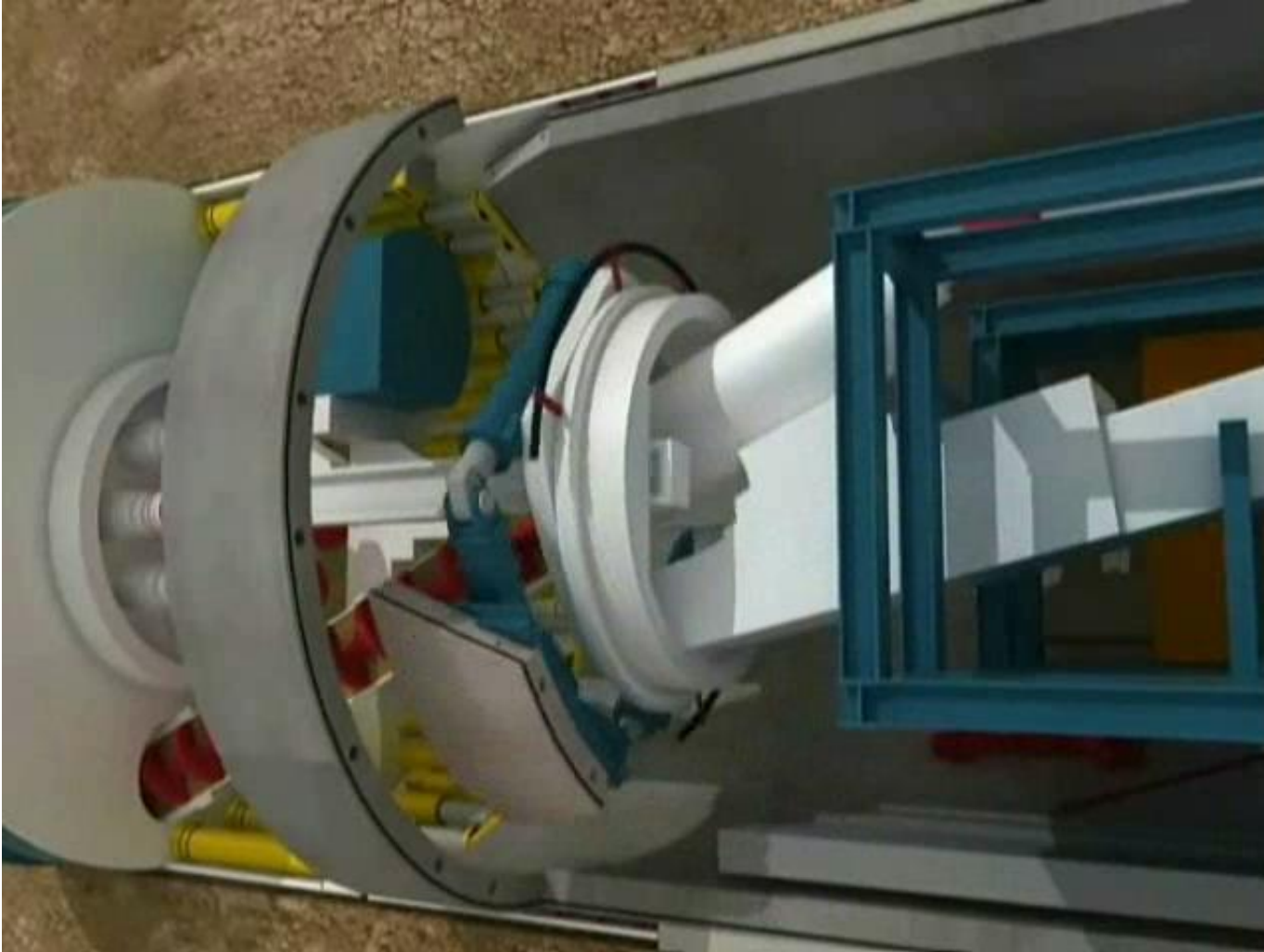


The concrete segments are assembled into a water-tight lining inside the shield; under the protection of the shield. No water, soil or rock enters the tunnel during construction



As the shield advances during tunneling three seals prevent water from leaking inside the TBM

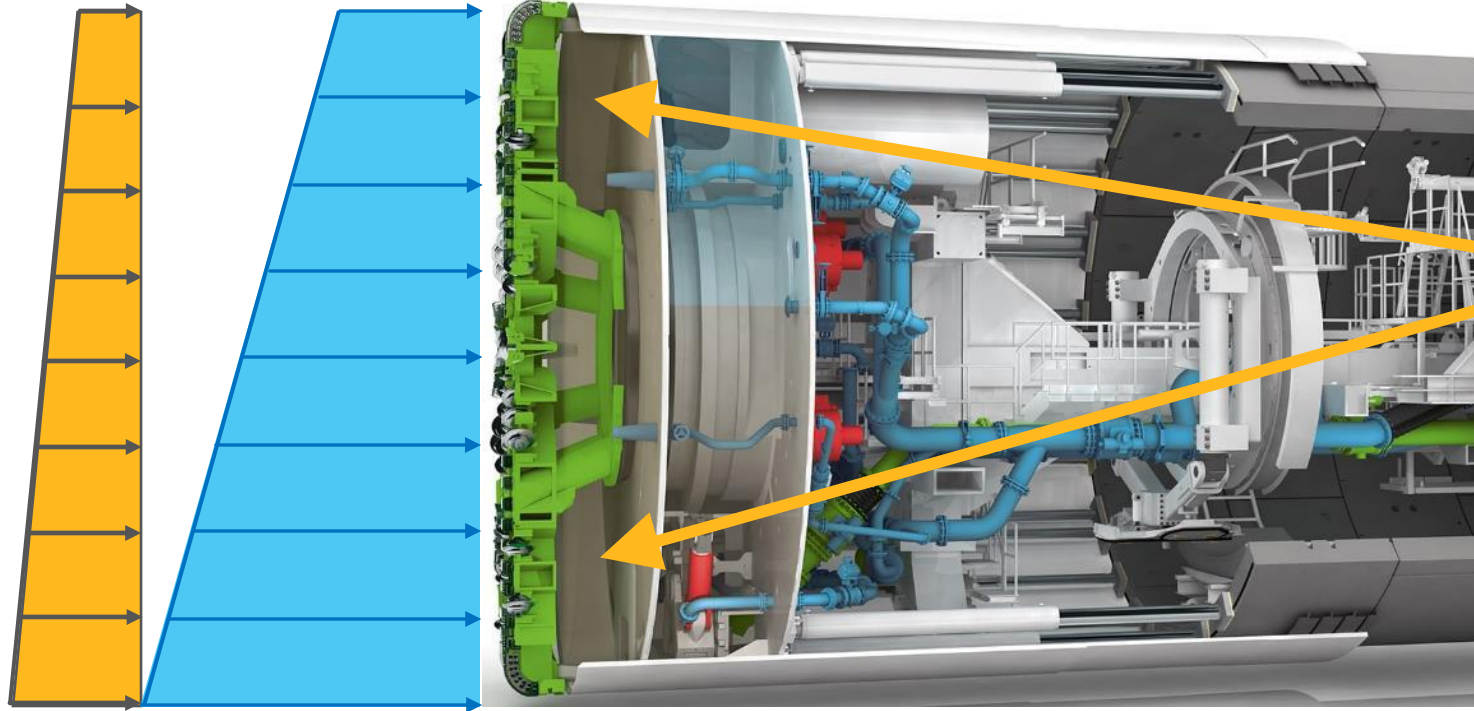
# Tunnel Grouting



- As the TBM advances, it pushes forward off the lining and simultaneously fills the void behind the lining with grout

# TBM Face Pressure

Earth pressure

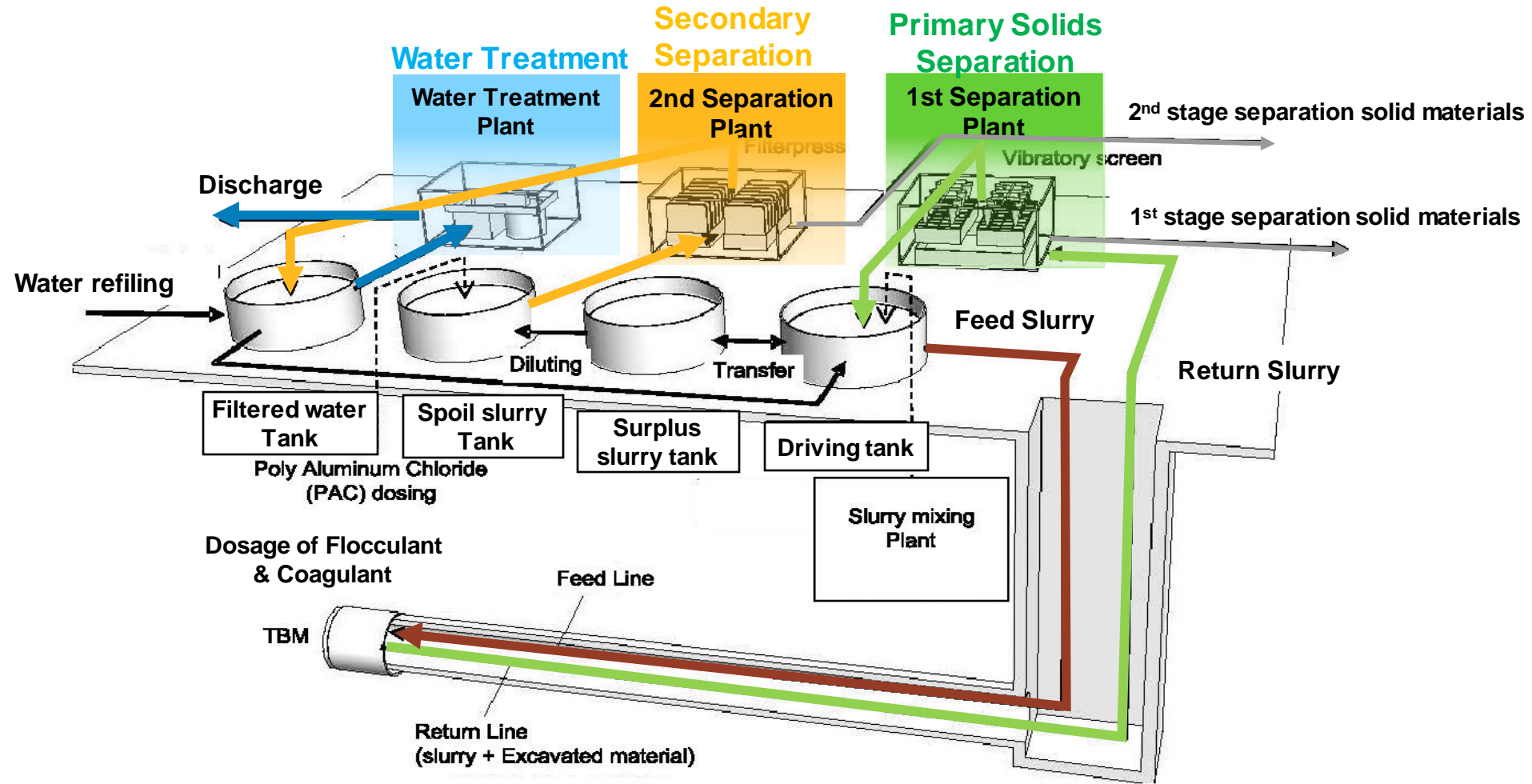


Bentonite slurry in the excavation chamber is pressurized to counterbalance the water and earth pressures that may act on the TBM face

Water pressure

The TBM has been designed to prevent any impact to the water in the Straits

# Tunnel Construction Separation Plant



# Other Construction Activities

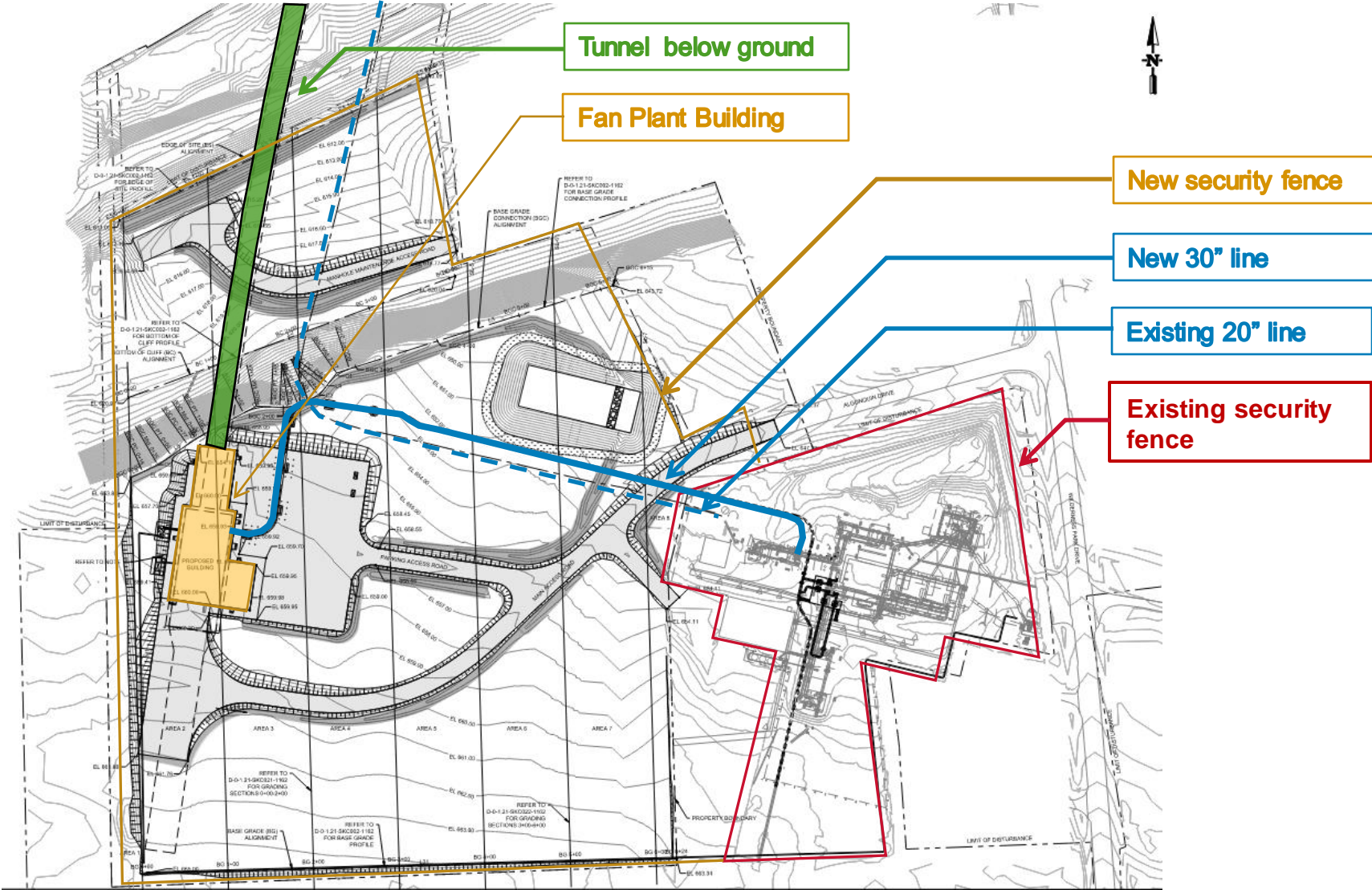


- Interventions
- Water Treatment
- Hazardous Gases
- Inspections
- Schedule
- Disposal of Excavated Material

# Operations

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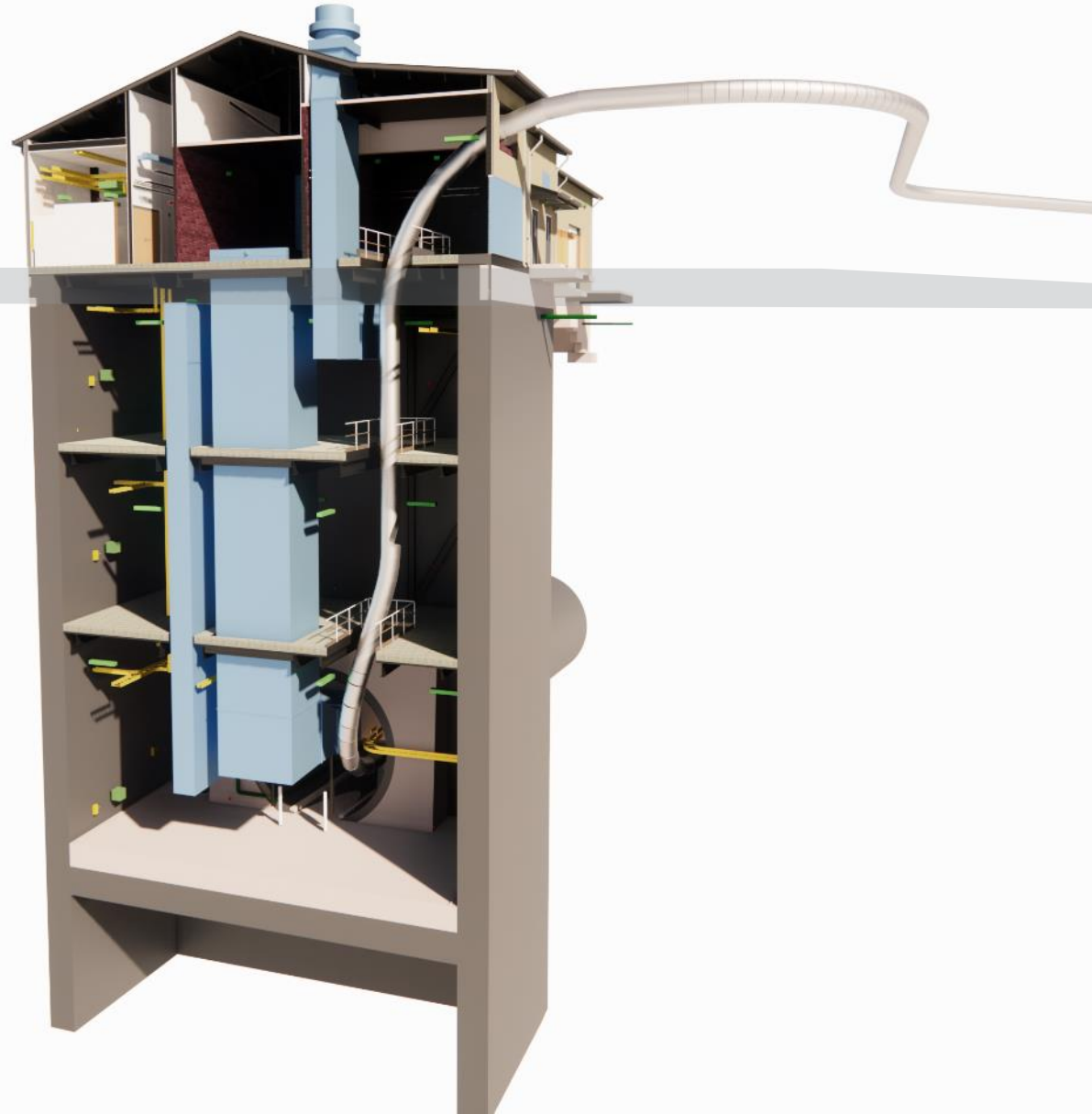
# Mackinaw Station



Operations

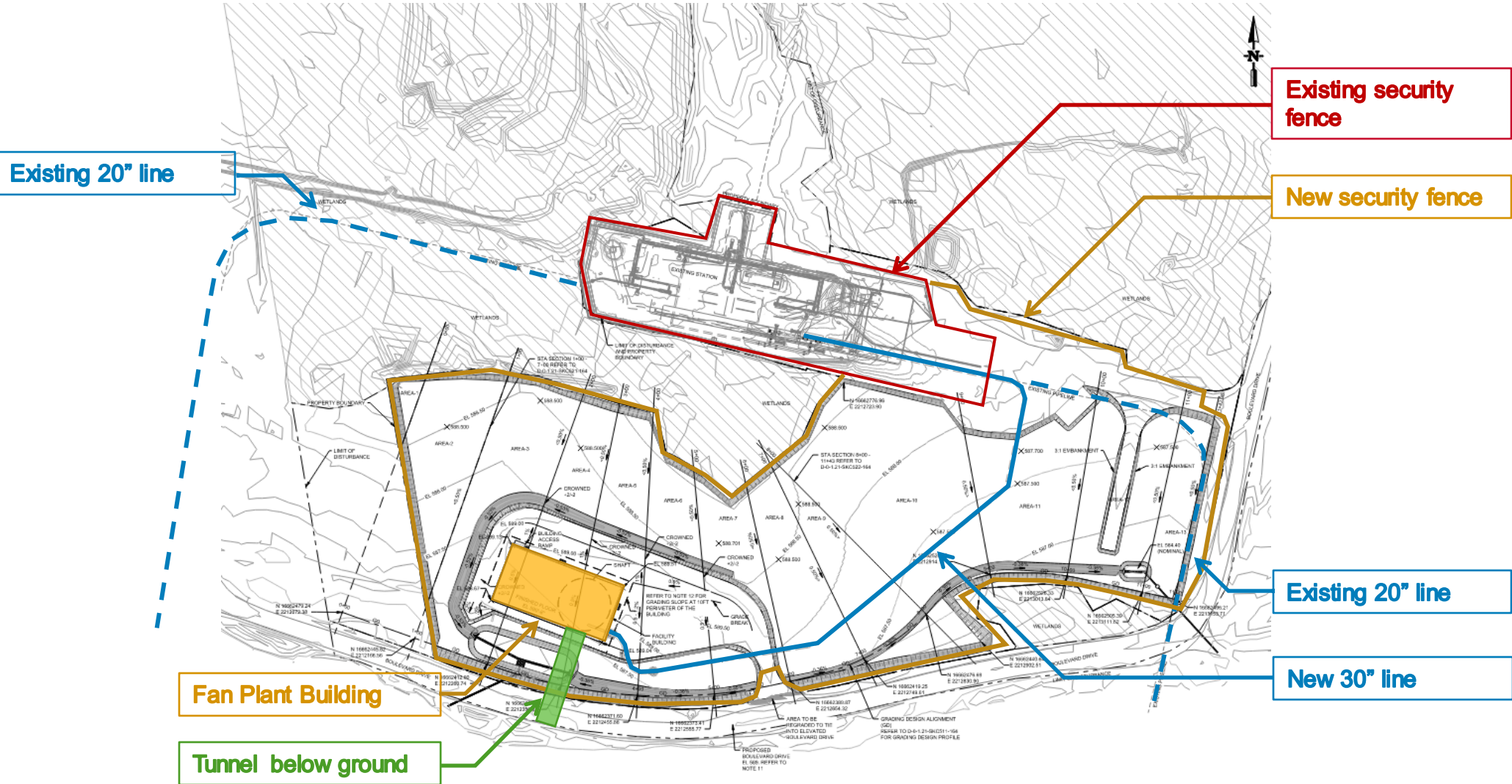
# Mackinaw Station Section View

Ground level



Operations

# North Straits



Operations

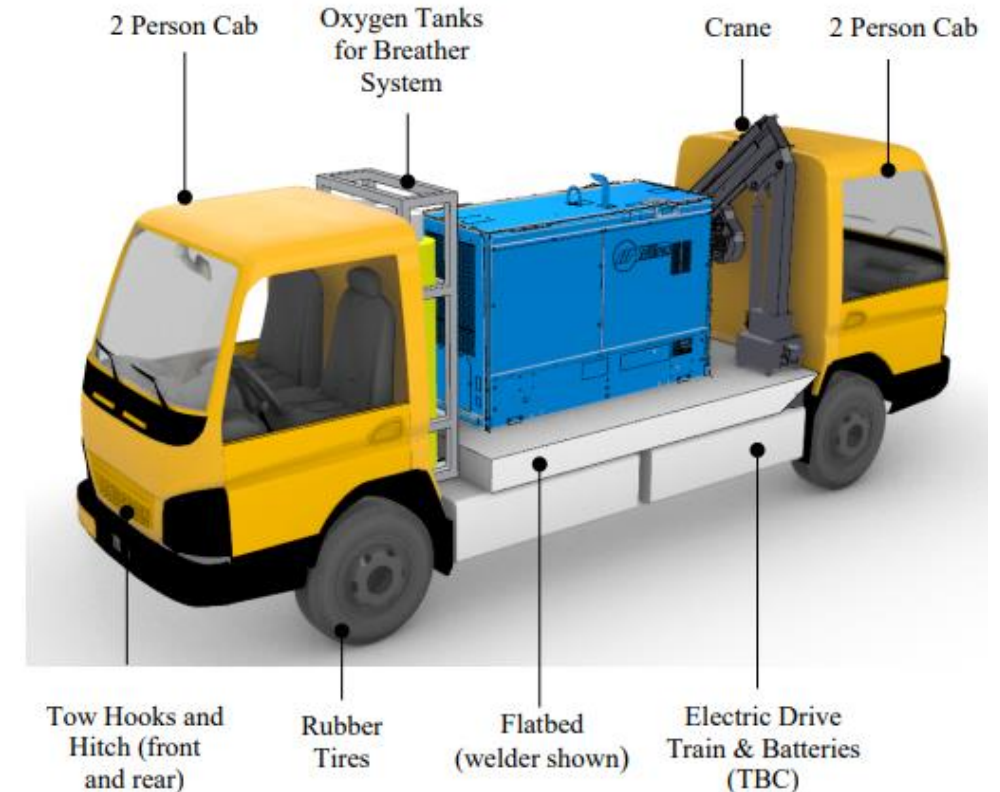
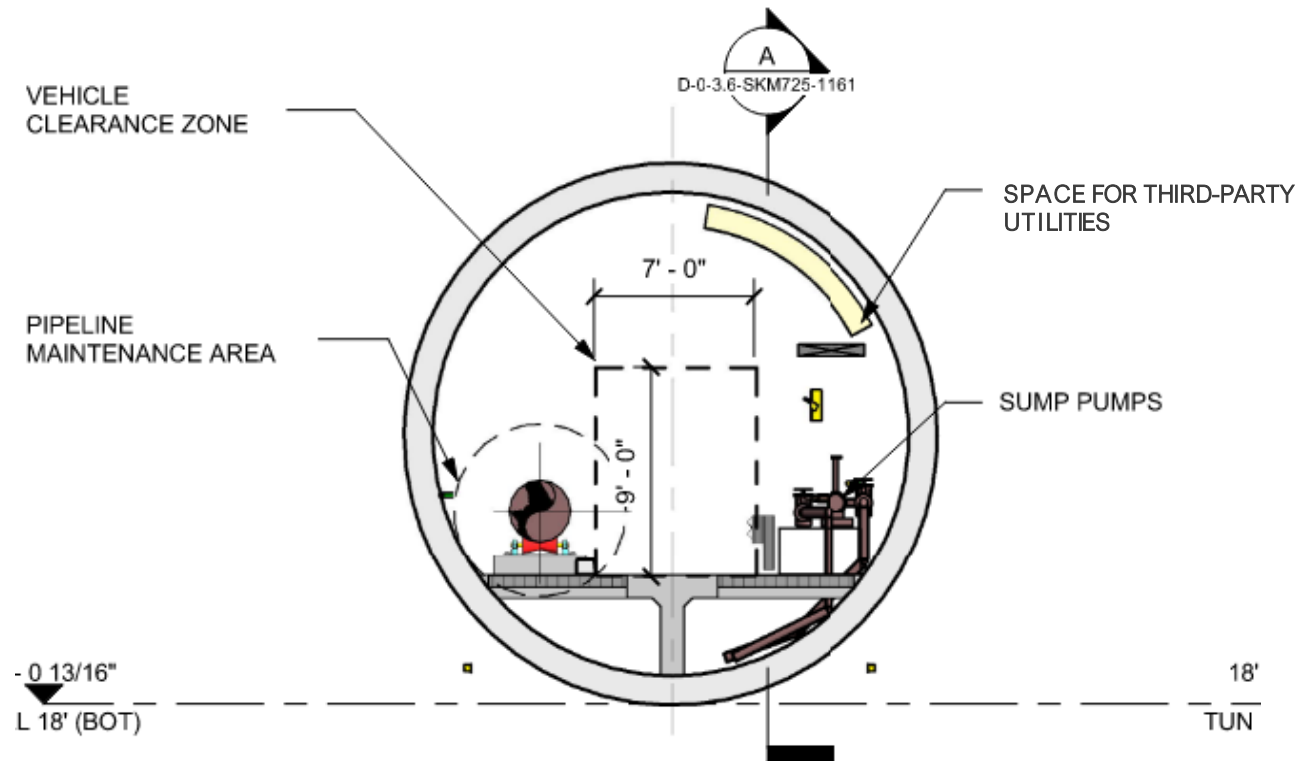
# North Straits Shaft Section View



Ground level



# Space Proofing & Maintenance

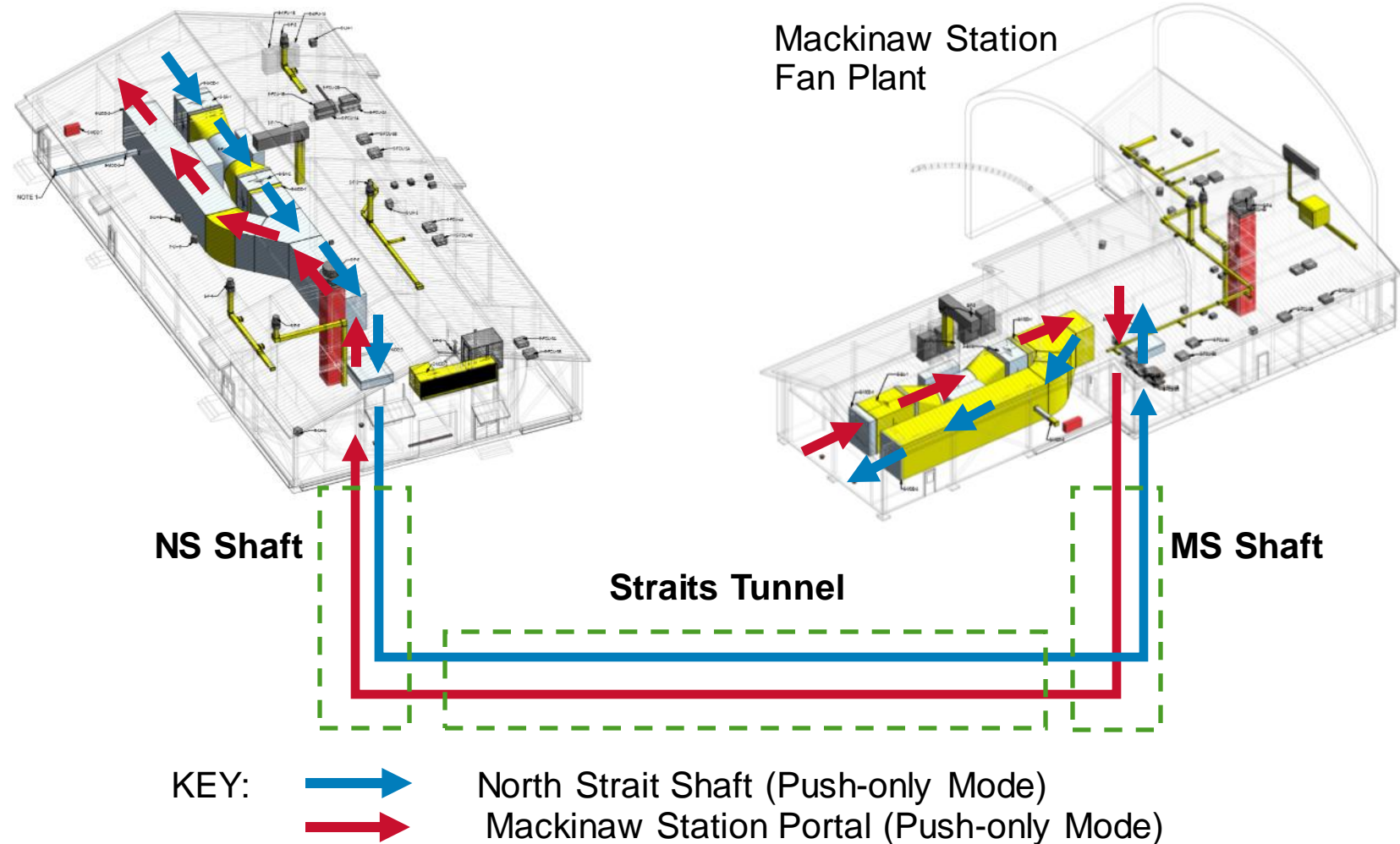


- Pipeline
- Tunnel Systems & Third-Party Utilities
- Third Party Utilities

- Maintenance Area – accessed using Tunnel Service Vehicle (TSV)

# Tunnel Systems Operations – Minimize Entry

## Tunnel Ventilation



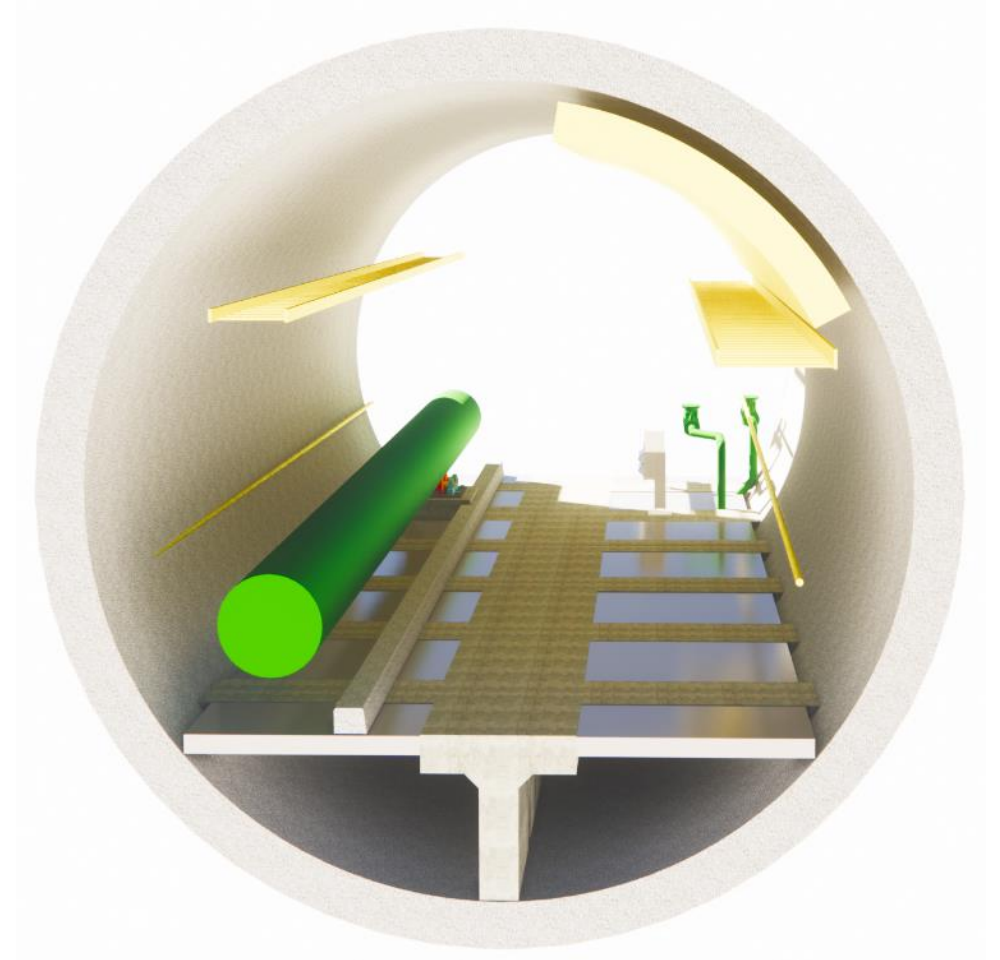
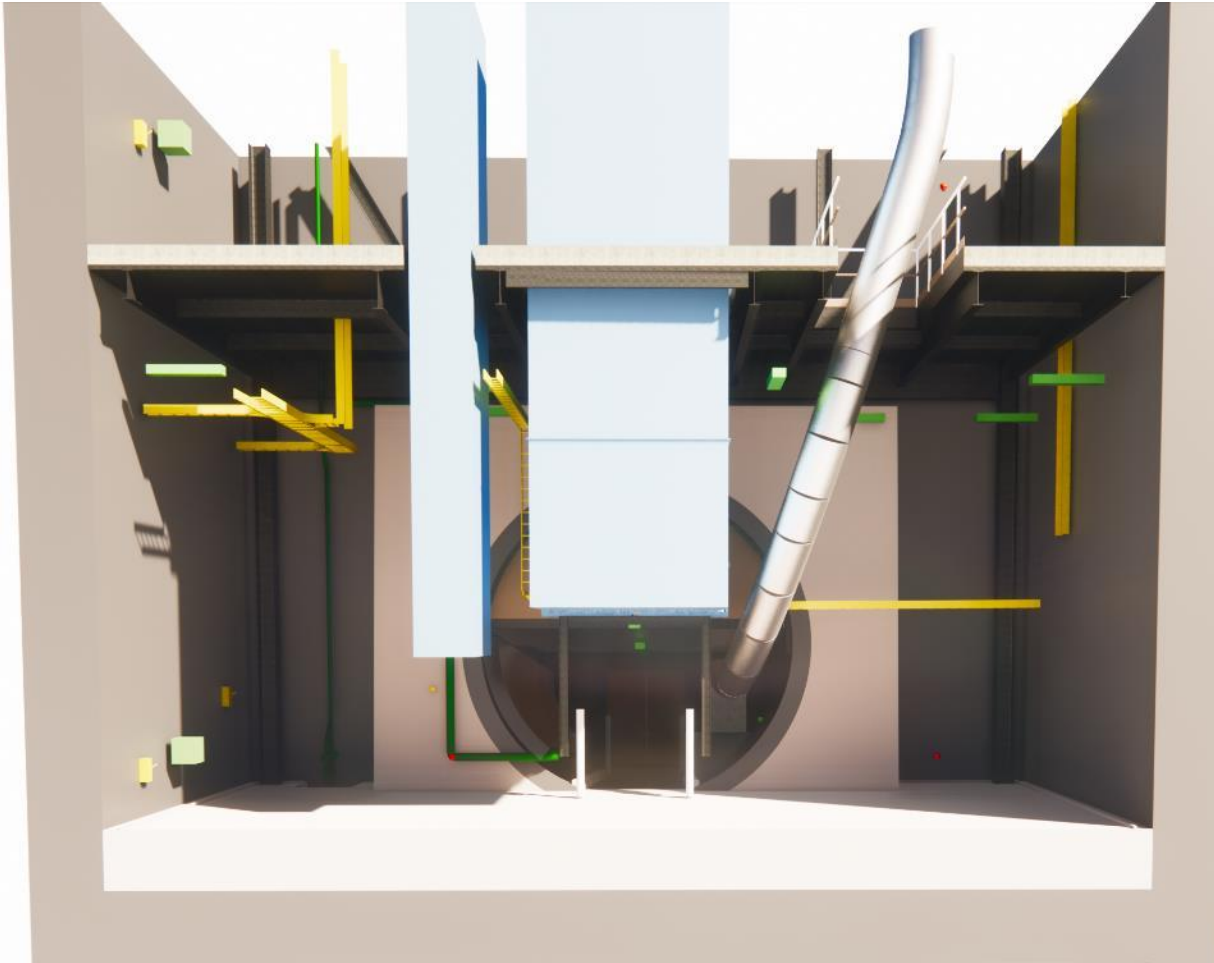
# Operations - Other Tunnel Systems

## Tunnel Systems

- Gas & leak detection
- Electrical & Communications
- Mine Phone
- Low point sump



# Normal Operations and Maintenance Activities



# RFP Process

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# Request For Proposal (RFP) Process



## The Process to Date

- In Jan 2019, Awarded Engineering and Pre-Construction Services contracts
- Constructability input received and incorporated into the design
- Delivery model provides for an opportunity to contract with the Pre-Construction services phase contractor or go to market
- Earlier this year expression of interest issued and submittals reviewed

## The RFP Package

- RFP is organized into two sections:
  1. Commercial
  2. Technical
- Key documents included in contractors RFP:
  - ✓ Instructions
  - ✓ Project scope description
  - ✓ Permit conditions
  - ✓ Specifications
  - ✓ Construction drawings
  - ✓ Geotechnical Reports
  - ✓ Other reference documents

## The Next Step

- Obtain MSCA concurrence